An Analysis of the Proposed Solutions to the Fermi-Hart Paradox

A thesis
submitted in fulfilment
of the requirements for the Degree
of
Master of Arts in Philosophy
in the
University of Canterbury
by

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University of Canterbury

2017

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Abstract

The Fermi-Hart paradox claims that there is a very high probability that detectable extraterrestrial intelligences exist, while also observing that we see no signs of them. This high probability of extraterrestrial intelligences arises from the sheer number of stars in the galaxy. Over the years many proposed solutions to this paradox have been developed. In this thesis I will analyse several of these proposed solutions using currently available evidence and attempt to determine if they provide a satisfactory response to the Fermi-Hart paradox.

Chapter 1: Introduction

Recent advances in our ability to detect extra-solar planets (exoplanets) have revealed that there are as many as one hundred billion **(NASA-JPL 2012)** of them in the Milky Way galaxy alone. This has led many to reconsider the likelihood of there being other intelligent life-forms elsewhere in the galaxy. After all, even if intelligent life develops on only a tiny fraction of planets, it still appears very likely, given how many planets there are in the galaxy, that it will have developed many times over.

The number of detectable extraterrestrial civilisations we should expect to exist within our own galaxy can be estimated by using the so-called "Drake Equation", which was framed by Frank Drake in 1961 (before the abundance of extra-Solar planets was discovered).

Drake Equation : $N = R^{*} F_{p} N_{e} F_{l} F_{i} F_{c} L$

Here the variables are as follows:

- R^{*}: The rate of the formation of stars suitable for the development of life. These types of stars exclude super giants, and stars that are in the galactic core.
- F_{p} : The fraction of those stars with planetary systems.
- N_{e}: The proportion of planets with a suitable environment for producing life.
- F_{l}: The fraction of planets suitable for life which actually produce life.
- F_{i}: The fraction of those planets with life that develops into intelligent life.
- F_{c}: The fraction of those intelligent species which produce a technological civilisation which is consequently detectable.
- L: The length of time that those civilisations are detectable.

From this we get N:

- N: The expected number of detectable civilisations in our galaxy.

1.1. Initial Analysis

The value of N, delivered by the Drake equation, varies depending on the approach used in the determining other values in the equation. Recent evidence suggests we should expect many of the variables to have relatively high values and thus we should expect a high value for N. For example, large numbers of earth-like planets have been recently detected, through efforts like the Kepler mission, around many stars in our galaxy. These new results suggest that the value of F_p and N_e are much larger than was previously assumed. Such exoplanets are detected mostly by the method of 'transit photometry' which measures the dimming of light from a given star as a planet transits in front of it. This method also enables the planet's radius to be estimated. Another method for detecting exoplanets is the radial velocity method which measures how much the star moves "wobbles" around its barycentre over time. If there is a planet orbiting the star this will lead to anomalous movement, which can be detected by measuring variations in the radial velocity of the star with respect to Earth. Thus far (as of February 2017) scientists have detected 2084 exoplanets and 1329 planetary systems **(Exoplanet.eu)** using these methods. Based on these observations, it is presently estimated that there are approximately 100 billion planets in the galaxy. Some of these detected planets appear to have Earth-like properties. For example, Kepler186f is similar in size to the earth, has an orbit of 130 days and orbits an m class dwarf, or a red dwarf star **(NASA 2014)**. This means that it should receive similar light and heat to the Earth (for although the planet's star is smaller than our sun, it orbits closer to the star). Earth-like planets in the habitable zones of their stars are now estimated to be very common **(Petigura et al 2013)** judging from the distribution of planets that have been found.

Estimates of the likely value of N_e (the number of planets with an environment suitable for producing life) and F_l (the number of planets which actually produce life) have likewise been raised by recent discoveries which suggest that life may potentially be able to develop on a greater range of planets, and moons, than previously suspected. Extremophiles are lifeforms that are adapted to live in environments which are so extreme that other forms of life cannot live there. These bacteria provide evidence that habitability could be extended to include previously unconsidered environments. Extremophiles have been found surviving, and thriving, in some of the most extreme environments on earth, such as in a lake under a half-mile of ice in Antarctica **(Siegert et al 2001**, **603)**. Microbial life has been found to colonise even radioactive waste **(McKinley et al 1997, 546)**, causing concern about how these microbes may affect containment procedures. Thermophiles and Hyperthermophiles live in extremely high temperature environments, from hot pools to deep sea vents where most life would die. The list is extensive. Bacteria have been found which live in highly acidic environments, highly alkaline environments, extremely salty environments, and highly pressurised environments. Moreover, it is not just bacteria which can be extremophiles. There is also a group of insects called Gryllobladditae, or ice crawlers, which are considered to be extremophiles because they live on ice fields and high mountain tops. Pompeii worms which live in oceanic hydrothermal vents are also considered extremophiles. The discovery of such life here on Earth expands the range of environments where we might expect life elsewhere in the galaxy, and so has far reaching implications for astrobiology **(Rampelotto 2010)**.

Estimates for the value of F_c (number of intelligent species which develop a technological civilisation which is detectable) depend on how an alien civilisation might render itself detectable. There are two obvious methods by which such a civilisation might be detected, one involving radio transmissions and the other involving spacecraft. The chances of an alien civilisation being detectable by radio are very low. They remain unlikely even if we were able to properly compensate for the effects of path-loss, whereby a signal is distorted by the distance travelled. The probability depends largely on the number of alien civilisations who have transmitted in our direction in the right time-frame **(Horvat 2006)**. For the probability to be significantly in our favour the number of civilisations broadcasting needs to be above 150 **(Horvat 2006, 7)**. Once the number gets above 300 civilisations the probability of detection is near certainty **(Horvat 2006, 7)**. The length of time of the broadcast window heavily influences the probability of detection. The fact that humans seem to be winding down our radio transmissions and shifting over to fibre-optic communication indicates that this window may be small. Programs like SETI, which primarily focus on searching for radio-wave broadcasts from extraterrestrial civilisations, will likely have a very low chance of success if the number of civilisations is small and the transmission window of those civilizations is limited.

The chances of alien civilisation being detected because of spacecraft appears much greater, especially if extraterrestrial civilisations utilise self-replicating inter-stellar probes as a cost-effective method of colonising the galaxy **(von Neumann 1966)**. Our galaxy is 100 thousand light years across. Even if the probes travel significantly below the light speed barrier, it might still take no more than a few million years to cross and colonise the entire galaxy. Since the galaxy itself is approximately 13 billion years old, this leaves abundant time for the galaxy to be explored by such probes. The likelihood of the value of F_c being high is further reinforced when account is taken of the possibility of probes being built to facilitate communication with other intelligent species, like ours, **(Freitas jr. 1980)**, not just for colonisation. Another factor to consider is that these probes would also serve to greatly lengthen the duration of the detectability of a given extraterrestrial civilisation which uses them, since the probes could continue to replicate and spread long after the civilisation that created them had faded away **(Cotta & Morales 2009)**. Due to the, possibly extreme, longevity of these probes they could potentially raise the value of L in the Drake equation, possibly by many orders of magnitude. This is dependent on these probes are actually being detectable, such uncertainty is due to our present difficulties in detecting such objects in space. As such, depending on which model is used, the quantity and detectability of such probes will have variable impacts on L **(Cotta and Morales 2009, 12)**. There are also various signatures of advanced technological civilisations that could be detected from earth, such as mining of extra-planetary objects which would leave tell-tale traces **(Forgan & Elvis 2011)**.

1.2. Possible drake equation values

Drakes' initial estimates for the various parameters of his equation were **(Drake &Sobel 1992, 55-62)**:

R_* = 1/year
f_p = 0.2-0.5
n_e = 1-5
f_l = 1
f_i = 1
f_c = 0.1-0.2
L = 1000-100,000,000 years

These values yielded an estimated value for **N** of somewhere between 20 and 50,000,000. New scientific discoveries and advances in understanding means that Drake's estimates require updating. Updated estimates for the values in the Drake Equation's parameters are as follows. NASA estimates that, based on current data, the rate of stellar generation in our galaxy is roughly seven stars every earth year (7py) **(NASA 2006)**. As yet it is unclear which proportion of these are suitable for the development of life or if any are not. The best guess value for the fraction of stars with planetary systems is that the average number of number of planets per star is 1.6 **(Cassan et al 2012)**. This determination was based on a statistical analysis of microlensing events. The study concluded that for a star to possess planets is the rule and not the exception as previously assumed. If this study is correct, then the number of planets in the galaxy is approximately160 billion.

The number of planets that are suitable for life is hard to properly quantify. The fraction of planets one might consider best candidates for having suitable environments producing life (roughly earth-sized in the habitable zone of their star) has been estimated at 22% **(Petigura et al 2013, 6)**. There is of course the problem that there are areas in the galaxy which would be unsuitable even if the above parameters are met. The Galactic Habitable

Zone (GHZ) consists of those parts of the galaxy which are not overly exposed to radiation (excluding stars near the galactic core) and that have the right levels of heavy elements. The number of stellar systems considered to be in the GHZ are 10% of the total **(Lineweaver et al 2004)**. This reduces the number of potentially habitable planets to about 2.2% of the total number of planets. Hence, if there are indeed 160 billion planets in the galaxy, it would follow that there are 3.52 billion planets that are suitable for life.

The values for f_l (the fraction of life-suitable planets which actually produce life) and f_i (the fraction of these planets where life evolves into intelligent forms) are difficult to properly assess. Judging by the fact that life developed very early in the history of the Earth, between 4 and 3.8 billion years ago, when Earth was only about half a billion years old, it might be tempting to assign a value near 1. The fact that it appears that abiogenesis only occurred once on Earth might be taken as indicating otherwise. This view is justified due to genetic evidence indicating that all life on Earth is descended from a single common ancestor, and thus that all life on Earth has a singular genesis. This situation could be due to our ancestor being the survivor of some early competition between multiple first lifeforms that arose independently of each other, but we have no evidence for this. If we were to base the value of f_l on what we currently understand of this process a best guess estimate for the fraction of planets in the habitable zone of the galaxy which actually produce life is 13% or greater **(Lineweaver & Davis 2002)**. It might be tempting to assume that life would also always necessarily tend to intelligence, giving f_i a value of 1 (as many have used). But a contrary line of thought is that because only one species in the tens of millions on earth appears to have developed sapient intelligence (namely, us), then we should assign f_i a low value. Hence the ample scope for disagreement with regards to f_i.

If we use a progressive model of human technological development it would appear that any suitably intelligent species would inevitably develop a technologically advanced civilisation. Thus, a value of 1 for f_c would appear to be obvious, especially if their development followed an exponential function, as human civilisation appears to follow. Such an optimistic view is not usually applied in formulating values for the Drake equation. Drake himself estimated that the fraction of intelligent species that developed to detectability would be 10% to 20% **(Drake &Sobel 1992, 55-62)**. The 0.1-0.2 value is disputable but is used quite often in the equation. The length of time these civilisations are detectable is also hard to find a settled answer for. Some have the value in the range of half a millennium **(Shermer 2002)**, but others in the millions of years. Shermer's calculations are based on the average length of time human civilisations last and thus are not exactly applicable to interstellar civilisations, especially ones which use robotic probes. For instance, our own space probes that are in orbit around our planet, and outside of the influence of atmospheric drag, may last millions of years. An assumed number may be in the order of one million years, considering the possibility of von Neumann probes and extra-planetary activity. It is, unfortunately, difficult to assign this value a "best guess" estimate. This is doubly unfortunate due to this value having, perhaps, the largest impact on the result of the equation.

If we plug in our (admittedly speculative) values into the Drake Equation, we get the following results:

$$N = 7 \times 1 \times 0.22 \times 0.13 \times 1 \text{ to } 0.1 \times 0.2 \times 1000000$$
$$N = 4004 \text{ to } 40040$$

These are not insignificant numbers of detectable civilisations, although, as previously stated, the value of L has a significant impact on the result. If we consider L to be larger, more civilisations become detectable and if we deem it to be smaller the number drops dramatically. An example would be if we reduced L to 500 we get a range of 2.002 to 20.02. It must be remembered that the numbers in the equation are disputed and these are merely best guess values. The Drake equation provides a useful tool with which to attempt to determine the likelihood of detectable extraterrestrial civilizations. The variables you choose to use in the Drake equation might be based on the current evidence but they are always going to be educated guesses. That being said it seems certain that numbers assigned to the variables, if based on good evidence, will be fairly reasonable. The equation itself is not the only reason to believe that extraterrestrial intelligences exist, though it does provide a useful method of analysing the relevant evidence we have. As previously stated, astronomy has revealed much about the abundance of extra-solar planets and biology has shown that life can exist almost anywhere on our planet, through these observations we can see that it is probably likely that life exists elsewhere in our galaxy. These provide evidence that we can translate to relatively high values for their corresponding fields within the equation with some measure of confidence.

1.3. Fermi-Hart Paradox

Consideration of the parameters of the Drake Equation leads to the problem, which will be the main subject of this essay: namely why is there a “silent sky”? That, is why have we not detected evidence of alien civilisations? Given that the Drake Equation seems to suggest a high probability of there being numerous detectable extraterrestrial civilisations in our galaxy, then why don’t we detect any? This problem is usually referred to as the ‘Fermi-Hart’ paradox after Enrico Fermi and Michael H. Hart. A precise statement of this paradox is this:

Fermi-Hart paradox: How is the apparent high likelihood of the galaxy containing numerous detectable extraterrestrial civilisations to be reconciled with the fact that we have not yet detected any such civilisations?

There have been many attempts to resolve the Fermi-Hart paradox. The rest of this thesis explores and evaluates the different solutions that have been proposed. Chapter 2 examines the so-called “zoo hypothesis”, this being the idea that aliens are intentionally hiding themselves from us. Chapter 3 considers the “trancension hypothesis” which rests on the suggestion that aliens are insular and undetectable because they have retreated into Matrix-like virtual realities of their own making. Chapter four and five will explore the so-called “great filter” hypotheses, which postulate that the number of extraterrestrial intelligences are severely limited due to various “roadblocks” in their development. Chapter 6 will look at the “they are here” possibility. Finally, Chapter 7 summarizes my results and attempts to assess which of the various proposed solutions are the most credible.

Chapter 2: The Zoo Hypotheses

There have been many attempts to resolve the Fermi-Hart paradox. This chapter will focus on one suggestion, which is that humanity is being intentionally kept isolated from alien civilisations much as if we were caged within a kind of cosmic “zoo”. Theories of this sort are collectively known as “zoo hypotheses”. These theories imply that the value of F_c in the Drake Equation is zero because alien civilisations are deliberately rendering themselves undetectable.

There are many Zoo Hypotheses, each of which posits a different reason for the non-detectability of extraterrestrial intelligences. They include the following:

1. Some rely on a variation on the “prime directive” of Star Trek fame, this being a civilisation-spanning policy of non-interference. The directive would require alien races to keep their existence hidden from less advanced alien civilisations like our own until some standard had been reached. (Perhaps humans must be allowed to progress naturally to a certain stage.)
2. Perhaps aliens are simply hiding from the human race out of fear that we may harm them. (Humans do appear to be a rather aggressive species.)
3. A more radical version of the zoo hypothesis has it that the Earth observes a simulation of the universe outside the solar system. This the so-called “planetarium hypothesis” **(Baxter 2001)**. The planetarium would prevent us from seeing the true universe, which (the thought goes) may well be brimming with intelligent civilizations. The planetarium hypothesis is often conjoined with the idea that the extremely advanced aliens who set up the “planetarium” will only let us participate in the true universe when they deem us “ready”.

2.1. The uniformity of intention problem

Each of the above suggestions can be criticised as suffering from a *uniformity of intention* problem (or "uniformity of motive problem"), because they rely on the assumption that all alien civilisations will collaborate in preserving and maintaining the "zoo". It would only take one civilisation to break compliance in order for the silence to end. Proponents of the zoo hypothesis must therefore posit some mechanism or compulsion to ensure that no extraterrestrial civilisation fails to cooperate.

Possible solutions to the uniformity of intention problem include these:

1. There are many civilisations but they keep silent out of fear of the first, dominant civilisation or some other super threat.
2. There are many civilisations but there is one dominant culture, perhaps the first due to some founder effect, and it has strongly influenced the attitudes of all others.
3. There are many civilisations but there is a universal moral code that all sufficiently advanced civilisations discover and abide by.
4. There are many civilisations but they all disappear due to some technological advancement.

The fourth response will be addressed in chapter three as it is part of a larger topic (see Trancension Hypothesis). For the time being I will focus on 1,2 and 3. The first approach proposes that civilisations fear some interstellar threat. The threats that could be proposed to explain these alien civilisations silence include some particularly dangerous alien species or a dangerous artificial intelligence. This interstellar threat may be immensely old, existing for, perhaps, billions of years. It doesn't particularly matter what the threat is, only that it is sufficiently fearsome as to ensure that these civilisations will remain undetectable. This is an undoubtedly ominous proposal. It differs from the initial proposal of the Zoo Hypothesis as these civilisations are not deliberately concealing themselves from less advanced civilisations. Instead they are hiding from a more advanced force. This seemingly mild alteration of the hypothesis actually significantly changes the proposed solution by rendering it unsupported and highly speculative.

The second approach claims that there was an early civilisation, either the first civilisation or perhaps the most culturally admired early civilisation, that became the model. This approach is an extrapolation of the phenomena that dominant cultures of any era influence the values and attitudes of those around them and those that come after them. We can accept this proposal more readily once we consider human history. It is similar to the idea of how European cultures since the fall of the Roman Empire have tried to emulate the idealised image of Rome. A modern example of this phenomena is the cultural dominance of the United States around the world. This is the sort of arrangement being proposed by the second approach, an extraterrestrial civilisation that has a large cultural influence on the other civilisation.

The third approach, that there is a universal moral code that all civilisations discover and abide by, relies on there being such a moral code. This in and of itself is a bold moral claim but much more than that this moral code is one which demands that these civilisations hide themselves.

Approaches two and three can be easily combined together to produce a more compelling variation of zoo hypothesis. Admittedly this variation will take more from the second response than the third response and this is largely because the third response claims that there is a universal morality. This is then expanded to claim that all extraterrestrial civilisations inevitably discover this moral code. The concept of a universal moral code which is discoverable by all intelligences, and is inevitably discovered, is delving into the subject of moral philosophy which is not the subject of this essay. As such I will incorporate the modified third approach above into the second approach and address them together.

> There are many civilisations but there is one dominant culture, perhaps the first due to some founder effect. This founder civilisation or culture has itself developed the ethics which all subsequent civilisations adopt due to these ethics being superior.

In this scenario the civilisations' values with regard to interstellar behaviour became universal due to some sort of founder effect **(Hair 2011)**. Thus this civilisation became the model of all future civilisations. It would appear that they had a moratorium of sorts against undue influence on emerging civilisations and, of course, colonization of said emerging civilisations **(Hair 2011, 132)**. This would prevent those extraterrestrial civilisations that followed from allowing themselves to be detectable to undeveloped civilisations. It is also important to consider that there could be millions, or billions, of years between the appearance of the "first" civilisation and those that follow **(Hair 2011, 134)**. The immensely old original galactic civilisation could then have unparalleled control over the affairs of other civilisations. Another outcome is that due to their advancement and great longevity that all others have emulated them to some degree including their ethics **(Hair 2011, 134)**. This possibility is greatly increased with the emergence of a *superintelligence* (an intelligence vastly beyond our own in all ways **(Bostrom 2006)**). If a civilisation managed to create a superintelligence then it stands to reason that a superintelligence should be capable of developing a system as described by the founder scenario, when the first (whether it is actually the first, or just the first known) civilization's culture and ethics dominates those that follow it by virtue of its being the first. By the very nature of a superintelligence its innovations would be beyond that of any non-superintelligence. This is especially the case if the civilisation possessed a machine superintelligence as this superintelligence would essentially be immortal. This immortality would allow the civilisation and its culture and systems of ethics to spread to any and perhaps all emerging civilisations and thus create the galactic system described by the Zoo Hypothesis. A possible problem for this superintelligence scenario is whether a superintelligence would behave in such a way. The assertion that a superintelligence would be interested in protecting new planetary civilizations from outside disturbance is difficult to assess at this point.

One criticism of the idea that a founder civilisation causes a uniformity of motive amongst the myriad of galactic civilisations is that the spatio-temporal separation between civilisations may be extremely great **(Forgan 2011)**. The existence of a type of hegemony between many civilisations would require an unbroken "chain of culture" to be established as each civilisation emerged **(Forgan 2011, 11)**. This seems to be unlikely considering that immense spans of time and distance could separate these civilisations. The spatio-temporal separation between civilisations are likely such that hegemony could never truly be established, whether the galaxy is crowded or not **(Forgan 2011, 12)**. This argument is largely irrelevant if we remember that the Paradox we are trying to resolve is strongest when exploratory self-replicating probes are proposed as the means of communication between alien races. It is possible that these probes could also be used to transport the ethics and ideas of whichever culture is sending them out. These probes would therefore be "life rafts" containing the culture and ideas of these civilisations. These cultural life rafts could potentially last for hundreds of millions of years in space, if not longer. However the idea that probes would be used for this purpose is highly speculative. The postulation of culture spreading probes is a further, and unsupported expansion of what we expect an alien culture to do. The postulation of a type of hegemony of ethics and culture transported by probes to explain the uniformity of motive appears to be an ad-hoc defence. This is because, at this point, layers of justifications for this hypothesis and its possible problems have been proposed. This appears to make the hypothesis a weak answer to the paradox.

This leads me to a larger problem with the zoo hypotheses, which is that it is grossly speculative and unfalsifiable. These are the problems of speculating unnecessarily with unfounded assumptions as to the behaviour and arrangement of extraterrestrial civilisations. The central hypothesis is that the silent sky exists because these extraterrestrial civilisations are purposefully hiding and making themselves undetectable. But how do we know this? Because we don't detect them. This is all that the hypothesis can say. Any criticism of this proposed hypothesis may readily be rebutted with some explanation of the assumed make-up of extraterrestrial civilisations and their political arrangements. We have no means of proving these ad-hoc assumptions wrong, but nor do we have any evidence for them. Of course, this does not mean that the zoo hypothesis is necessarily wrong. The hypothesis may in fact be the correct one but before we opt to believe it we should first look to see whether there is an alternative, more satisfactory answer, that is more readily falsifiable and less speculative.

Chapter 3: The Transcension Hypothesis and Isolated Transhumanism

The Transcension Hypothesis **(Smart 2012)** proposes that as civilisations advance they develop ever more advanced, denser and smaller computing devices and then integrate themselves into these devices. This facilitates ever smaller and computationally faster minds with larger intellectual capacities and higher efficiencies, particularly in terms of energy consumption. The ultimate result of this process is a population of hyper intelligent, potentially immortal entities which are approaching Planck-scale limits of size.

These civilisations cease to be detectable as they become ever smaller. This results in civilisations which have followed the process of transcension no longer being observable. As Richard Feynman more than half a century ago noted "…there is plenty of room below" **(Feynman 1959)**, so it should not be very surprising if advanced civilisations tend to become hyper-miniaturized and disappear into "micro-space". As they become physically smaller, and hence computationally faster, processes in the rest of the universe will appear, from their perspective, to slow down. Communicating with other intelligences such as ourselves would plausibly be a tedious and uninteresting affair for such super-intelligent beings. If the Transcension Hypothesis is correct then alien intelligences won't expand throughout the universe in the way science fiction writers typically imagine. They will instead pursue smaller and faster computer technologies and go on to explore virtual worlds and the possibilities therein. This is a process whereby technology is pursued in a progression toward very small scales of space, time, energy and matter, referred to by Smart **(2012, 3)** as "STEM". According to Smart, such STEM development inevitably leads to civilisations essentially disappearing from the rest of the universe.

The Trancension Hypothesis rests on the assumption that all extraterrestrial intelligences no matter how they might initially differ from each other share the same drive towards developing better, and hence smaller, faster and more efficient, computational technology which eventually culminates in them migrating into an "inner space" **(Smart 2012, 1)**.

The Transcension Hypothesis is similar to the zoo hypotheses in implying that alien civilisations are insular and undetectable. However, it differs in that it doesn't imply that alien civilisations are purposely making themselves undetectable or purposely not communicating with human beings. Rather they simply disappear into their digital universes and loose interest in the, to them, very slow and dull, physical universe.

It might appear that the Transcension Hypothesis falls prey to the same objection that undermines the Zoo Hypothesis, namely that it assumes a universal intention on behalf of alien civilisations. Specifically, it assumes that all alien civilisations will follow the same path of technological progression and eventually end up disappearing into inner space. However, a universal intention seems somewhat plausible in this case. It can be expected that sufficiently advanced extraterrestrial civilisations will at some point develop computers. The subsequent development of computer technology should tend toward smaller and faster computer devices. This process is all it takes for the progression toward Transcension, according to the hypothesis.

3.1. Transhuman influences

Before I examine the Transcension Hypothesis in detail it will be useful to examine a closely related theory, known as transhumanism.

Transhumanism deals with the ideas of humanity and its integration with technology in order to enhance itself and eventually develop into a post-human species. The so-called "technological singularity" is the point in this process at which artificial intelligence has developed far enough that it can improve itself, and do a better job of designing new technology than we can. Artificial intelligences then are able to upgrade their own intelligence without further help from human beings. This leads to a dynamic of rapidly accelerating computer intelligence, and an "event horizon" beyond which it is difficult to make predictions (since we cannot easily foresee what will be done by beings more intelligent then ourselves). There are two major differences between the Transcension Hypothesis and transhumanism. Firstly transhumanism deals with humanity almost exclusively whereas the Transcension Hypothesis applies to all intelligences in the universe. Secondly the Transcension Hypothesis and transhumanism differ in the area of emphasis. Transhumanism makes a normative claim about the desirability of humanity setting the dynamic of the singularity in motion. The Transcension Hypothesis instead makes a descriptive claim about the nature of intelligent species and their inevitable development.

The Transcension Hypothesis broadens the ideas of transhumanism to claim that alien civilisations are liable to follow the same path of integration with technology that we are probably about to take.

It is also worth noting that you can support one of these theories without supporting the other. You can believe that humans ought to integrate with our technology and through this become better and more advanced without believing it is an inevitable process experienced by most, or all, intelligences in the universe. Conversely you could believe it is an inevitable process but not that we ought to do it. A person with the latter view would have a fatalistic attitude to the forthcoming singularity.

The core idea within Smart's Transcension Hypothesis of the ideas just described, namely, that the intelligent civilizations inevitably integrate into their computers and become hyper-miniaturised super-intelligences who in effect disappear from the universe. It will therefore be useful to coin a new term that will be reserved for naming this core idea. I will introduce the term "isolated transhumanism" for this purpose. The name is based on the very great similarities between Smart's ideas and those of the so-called transhumanists, who believe that humans are themselves are destined to port themselves into their own computer technology.

3.2. Other components of Smarts Transcension Hypothesis

I have just described the core components of the Transcension Hypothesis. It is worth noting that Smart, who is the argument's originator, also has other, more speculative ideas that he incorporates into the hypothesis.

Smart proposes the application of evolutionary developmental biological principles to civilisations and the universe. This Evolutionary Developmental Universe model proposes that most processes are unpredictable and essentially chaotic within the universe and these form the evolutionary processes. A few processes are predictable and are therefore the developmental processes.

This model of the universe also posits that the developmental tendency of the universe is toward increasing complexity which Smart **(2012,4)** defines as: “the number of unique structures and functions expressed in a system”. He supports this by the idea that as the universe has progressed things have become more complex from the first stars to multicellular life. This increasing complexity has produced smaller and more localized complexity **(Smart 2012, 4)**. Therefore, it is proposed, things develop toward smaller more complex systems, which is the consistent theme of the hypothesis and is described as increasing spatial locality (space density and efficiency **(Smart 2012, 4)**) .

Smart proposes that this tendency of the universe can be observed in human progress. An example he uses is the increased spatial locality and STEM density demonstrated starkly in the increasing urbanisation of the world, which has the effect of more people live in smaller areas of land. Smart supports this position by citing the statistic that three percent of the land in the United States being occupied by seventy nine percent of the people **(Smart 2012, 5)**. Smart also emphasises how cities are more efficient as they get denser.

The most contentious aspect of this developmental proposition within the Transcension Hypothesis is that these hyper advanced intelligences eventually migrate to the event horizon of a black hole (or create one) as optimum places for themselves. In this way alien civilisations truly disappear from the universe.

In what follows I will leave these issues mostly aside (except for a brief discussion of Black Holes). Instead the focus will be on the central idea that intelligence leads naturally to computers and computers lead naturally to “isolated transhumanism”.

3.3. Why should we think this is true?

Reasons to think there might be an inevitable, or near inevitable, tendency for civilisations to undergo a process of "isolated transhumanism" include the following:

First, humanity appears much more interested in investing in computer technology than in exploring space. This focus on computer technologies can be seen in the rapid improvement in video game and other digital technologies. An example of this rapid progression is readily observed when we contrast the video games of the 1990's, which had characters who appeared to be comprised of blocks and game worlds which were very simple, to the 2010's video game technology which can produce amazingly photo-realistic characters and highly detailed game worlds full of complex features. Another reason to believe that this trend may hold is the rapid increase in the number of transistors within an integrated circuit, which equates to computing power. This best expressed through Moore's law which states that the this increase in transistors in an integrated circuit would double every two years **(Tuomi 2002)**. While its future predictive utility may be in doubt it has none the less been an accurate model of the advancement of computing technology in the decades since it was first proposed in 1965. The doubt as to Moore's law's ability to maintain its predictive utility is down to the size constraints of our current technology, though Moore's law has survived previous technological limitations and transitions before **(Bostrom 2006)**. The use of human behaviour as an expectation of what all intelligent species will do, and have done, may be regarded as an invalid assumption. The fact is we have only ourselves to really draw on when it comes to what a technological civilisation will do. Though we are just one instance of an intelligent species this "sample of one" can still provide some predictive utility. It largely depends where on the bell curve we expect humans to sit in relation to other intelligent species. The statistical probability is that we should expect to be near the centre of the bell curve and thereby be statistically average. As such we should expect to exhibit similar tendencies with regards to our investment in technology as other intelligent species.

The second reason concerns the process of increased spatial locality which is primarily directed toward computing systems, which intelligences are supposed to migrate into once it is possible. This STEM compression can be observed in our own computer devices today. Consider that just forty years ago computers took up whole rooms in universities and scientific institutions, while today a computer can fit in your pocket and is many, many times more powerful. The rapid advancement of computing power along with the dramatic reduction in the size leads to an increase in the density of the computational power—which is to say, STEM compression. This can be seen as an expression of Moore's law in action. As transistors become smaller the density of them in an integrated circuit will increase, and as such computing power will increase rapidly while the computers themselves will become smaller.

The speed of the advancement of computer power is remarkable. While it would take evolution millions of years to increase the intelligence of a brain, if it would at all, humans have been able to increase the relative intelligence (computational power) of computers relatively quickly and following Moore's law this is expected to continue. It is reasonable to assume that there may be some limit on exactly how long this can actually continue. The hypothesis makes it explicit that the size of these computational units is a factor. It is expected that these will become atomic scale computers. This is expected to come as a result of the technological singularity, whereby true artificial intelligence is created. Whether the technological singularity or atomic scale computers come first (or at all) is up for debate.

Lastly is that porting yourself into computers provides multiple gains. With the advent of computers which are vastly more powerful than our own there would naturally come many benefits to porting your mind into them. Initially it would probably be with the intention of still having a presence in the real world, with a robot body or some other interaction-facilitating device. With more and more individuals uploading themselves the need to interact with the real world would quickly diminish until interaction with the real world would become incredibly unlikely.

Becoming a computer mind would result in many gains such as:

- Immortality.
- Speed based intelligence.
- A very rich virtual world to exist in. We can expect this world to provide more entertainment then the real world, by virtue of its near unlimited potential. At the same time the real world would become comparatively slow and tedious due to the increased speed of mental processing power.

At this point it is obvious that in order to hold this position you must also hold the position that the mind can be replicated within a computer, or at the very least a computer can have a mind. This position is often called functionalism. If we hold functionalism to be true then it can be easily assumed that you can replicate your mind within a computer. If you do not hold the position that you can reproduce a mind within a computer then you most likely will not hold "isolated transhumanism" as a likely solution to the Fermi-Hart paradox. One concern which might be raised is that if functionalism is false and you attempt to upload your mind into a computer, because you believed functionalism was true, you would have a high possibility of becoming a "zombie". This outcome would mean that whilst the computer-mind version of you may appear to be exactly like you to someone interacting with it (it would answer questions as you would and it would behave as you would) it would not have conscious mental states. This sort of situation can be illustrated by Searle's Chinese Room argument **(Searle 1980)**. In Searle's argument you are in a room whereby people are passing you questions from outside the room, these questions are written in Chinese characters which are unintelligible to you. This is not a problem because you have a book, written in English, which gives you instructions on how to respond and thus you respond as instructed **(Searle 1980, 420)**. The people who receive your responses are justified in believing that you understand Chinese and are genuinely answering their questions, but you don't understand their questions and you have no beliefs or feelings regarding your responses as you are merely doing as instructed. In this way Searle attempts to demonstrate that a computer could look as though it has understanding and, subsequently, mental states when it does not **(Searle 1980, 420-421)**. Thus it could appear that the uploaded mind is you when it is more like the Chinese Room version of you, merely following the instructions of your mind-program without any of the mental-states associated with true consciousness. Nonetheless, in order accept this response to the Fermi-Hart paradox you must believe that a computer can reproduce a mind, and not just a create a zombie version. Along with this, we must also believe that alien intelligences will also hold this same position. We must not only believe this but we must also claim that all or most intelligences in the galaxy, at least, will come to this conclusion. If claiming that computers can replicate minds is a true position then it is likely that most intelligences will come to hold this position. Being optimists we should hope that intelligent beings will sooner or later come to hold mostly true positions. This is a pivotal claim within “isolated transhumanism” that one must hold to be, at least probably, true in order to believe that it is likely.

3.4. A new vision of advanced civilisations

This hypothesis is to be contrasted with an expansionist model of civilisation development which states that civilisations will expand throughout the galaxy **(Smart 2012, 4)**. Rather than expand throughout the galaxy the hypothesis proposes that these civilisations instead turn inward and develop smaller and smaller computational devices in which the minds of the civilisations reside. The hypothesis counters the Kardashev scale, which describes the level of development of a civilisation by its total energy use. This method of categorising civilizations was originally formulated by Nikolai Kardashev in 1964 **(Kardashev 1964)**. The scale was proposed as a method of evaluating what types of civilization we should expect to be able to detect **(Kardashev 1964, 220-221)**. The Kardashev scale classifies civilizations from type 1 to type 3, where a type 1 civilization uses the total energy of its planet, a type 2 civilization is able to harness the entire energy of its star, and a type 3 is able to use the entire energy of a galaxy **(Kardashev 1964, 219)**. The Transcension Hypothesis instead suggests that a measure of civilisation is its efficiency and STEM compression **(Smart 2012, 6)**. This means that it is unlikely that a truly technologically advanced civilisation would deem it necessary to extract the energy of multiple suns or build the mega-structures imagined in science fiction. Instead the limits of technology would be on how small they could feasibly engineer and on how efficiently they could use energy, not on how large their energy network would be. The possibility of Planck-scale computers is proposed, though it is debatable if these are truly possible. The emergence of superintelligence within this scenario would be the catalyst toward the ever smaller and more efficient computational technologies not toward an expansive multi-planetary civilisation. This reduction in size would not only lead to greater efficiency but also faster processing speeds. It is likely that this size reduction would be motivated by the desire to produce faster computers and not necessarily the energy efficiency which results from it.

3.5. A black-hole civilisation

The primary advocate for the Transcension Hypothesis is John Smart. Smart draws three connections between the Transcension Hypothesis and black holes. I now discuss these briefly, with the sole aim of demonstrating that they are, at best, unnecessary ancillaries to the hypothesis itself.

The first connection he draws is an analogy involving immense STEM compression and lack of communication with the outside world. The analogy with a black hole is fairly obvious. The idea of the Transcension Hypothesis is that as these intelligences migrate to super small and dense computers, giving rise to a rapid increase in STEM density, civilisations become undetectable in the universe. It would also lead to the civilisation shrinking into an incredibly dense computational "particle".

The second connection Smart makes moves beyond analogy, he claims that these intelligences actually become semi-pseudo black holes. This is due to the proposed "black-hole-like" conditions of maximum STEM compression **(Smart 2012, 6-7)**. This state is posited to occur due to the phenomenal energy density which occurs at this point. These intelligences would proceed to convert much of their solar system into these computer-particles, which would create a super-dense computer whose properties are claimed to be "much like an artificial neutron star" **(Smart 2012, 8)**. This highly massive, in terms of mass but not necessarily size, "structure" would then slowly siphon off the matter and information of the parent sun. To the outside observer Smart claims that this structure would appear as a "low mass x-ray binary" (a small black hole or neutron star which slowly consumes another star) **(Smart 2012, 8)**.

Finally, Smart suggests that these computational minds would have sufficient reason to migrate to the event horizons of black holes. This would be to exploit the unique physical conditions that obtain there. Smart **(2012)** proposes that this is an inevitable outcome of the process of transcension. These transcended civilisations could survive the forces involved in migrating to the event horizon of a black hole through the use of femto-technology **(Smart 2012, 7)**. Smart claims that this migration is desirable due to the unique physics of black holes, for instance the time it takes to flip a bit at any location is the same as it takes to communicate to any other point around the event horizon **(Smart 2012, 7)**. This leads to instantaneous computation. A by-product of this situation is that these computer civilisations are totally undetectable to the rest of the universe. More radically, Smart advocates this as a form of time travel to the future, whereby all such civilisations would merge **(Smart 2012, 7)**. This merging occurs because, according to Smart, all such black-holes in the galaxy (and the ones in Andromeda, as it will collide with ours) will one day merge **(Smart 2012, 7)**.

What are we to make of these ideas? In my view they are very speculative. In this they should be separated from the more plausible elements of the proposal itself. In this way we arrive at the core idea of "isolated transhumanism", which appears to be a plausible solution to the Fermi-Hart paradox. While the black hole proposal is interesting it is too speculative and it is an unnecessary addition to the core hypothesis itself. In addition, it is also presently unknown whether all the black-holes in our galaxy will or will not merge together. The position that all black holes will merge is unsupported.

Chapter 4: The First Great Filter

The previous two chapters have discussed two answers to the question, "why the silent sky?" namely, the Zoo Hypothesis and the Transcension Hypothesis. I now will turn to another type of answer, involving a "great filter". This chapter and the next chapter discuss two commonly proposed "great filters". The First Great Filter is based on the idea that intelligent life is *rare*. The Second Great Filter is instead based on the idea that intelligent life is although perhaps common, very prone to destroying itself before it can be detected. The present chapter discusses the first great filter and the next discusses the second great filter.

When framed in terms of the Drake Equation, the idea of the first great filter is that one or more of the following parameters has a low value:

- N_e, the proportion of planets with a suitable environment for producing life.
- F_l, the fraction of planets suitable for life which actually produce life.
- F_i, the fraction of planets that actually produce life where the life evolves to become intelligent **(Lineweaver 2008)**.

Theories which could be said to invoke the First Great Filter are usually concerned with the probability of various developmental stages of life. There are many significant steps in the development of an intelligent technological species which could potentially be very improbable. These include:

I. The existence of a suitable planet.
II. The advent of the first self-replicating molecules and cells.
III. The advent of multi-cellular life and sexual reproduction.
IV. The advent of life-forms with central nervous systems.
V. The advent of human-level intelligence.

Any one of these evolutionary steps could act as a filter on the development of complex intelligent life. Different versions of the First Great Filter argument focus on different steps in the chain above. I will now consider a few of these theories, beginning with the so-called "Rare Earth Hypothesis".

4.1. The Rare Earth Hypothesis (REH)

The REH proposes that planets which have the capacity to produce complex life (or *any life* in stricter forms of the hypothesis) are very rare due to the sheer number variables which must "line up". In other words, this hypothesis proposes that the first step in the above sequence of stages has a very low probability.

Unfortunately, we as yet have no clear understanding of the conditions that a planet must satisfy in order for complex life to evolve. This means that arguments for and against the REH are usually highly speculative. It might be thought that the REH is false, given the frequency with which new "earth-like planets" have been discovered in recent years. The first such planet was discovered in 2007 in the form of Gliese 581c **(Udry et al 2007)** (although this planet's earth-like status has since been doubted due to its closeness to its parent star). As of mid 2016 the number of potentially earth-like planets that have been detected is as high as forty four **(PHL r25/09/2016)**. All of these planets have been found in our own galaxy and given that the technology and techniques used for detecting these planets are still in their infancy, it would appear that such planets are very common indeed.

However, this argument rests on a serious misconception concerning the nature of the so-called "earth like planets" that have found. As a case in point, consider Gliese 832c (also called GJ 832c). In 2014 (when it was discovered) it was heralded in the popular press as "one of the top three potentially habitable planets" and that it was "just 16 light years away" **(Prigg 2014)**. Because it was larger than Earth (at 5.4 ± 1.0 Earth masses **[Wittenmyer et al 2014, 1]**) it was termed a "super Earth". It was described as such because it was thought to be a rocky planet like Earth, and because it was in its star's "habitable zone" (albeit very near the inner edge of this zone). However in reality Gliese 832c is very unlikely to be habitable, or at all similar to Earth. Even its discoverers noted at the time of its discovery, that it is probably more of a “super Venus” than a “super Earth” **(Wittenmyer et al 2014)**. (This didn’t stop them titling their paper *“GJ 832c: a super-earth in the habitable zone”*.) Gliese 832c’s large mass means that it likely has a very thick atmosphere and thus probably a powerful greenhouse effect. It’s position near the boundary of its planets habitable zone means that the surface temperature is probably sufficient to melt metals like lead and bismuth, as on Venus. Its orbit around its star is 35.8 day which indicates a high probability that it could be tidally locked to its parent star **(Wittenmyer et al 2014, 8)**, so that one side of the planet is eternally baking in the sun and the other shrouded in darkness. This does not mean that the night side would be frozen, as with such a thick atmosphere the heat would likely be trapped and channelled around the planet via winds. It is likely that the discrepancy in temperatures between the night side and the day side would generate large storms that would dwarf hurricanes on Earth in size and power. All in all, this so-called “earth-like planet” is not likely to be very earth-like at all. It is probably host to a hellish surface environment.

Astrophysicists determine if a planet is “earth-like” using a what is called the “Earth Similarity Index” (ESI). The ESI is a scale which measure’s how much a planet should resemble the Earth based on four variables: radius, density, escape velocity, and surface temperature. These are then factored together using the following calculation **(PHL r01/08/2016)**:

$$\mathrm{ESI} = \prod_{i=1}^{n}\left(1 - \left|\frac{x_i - x_{io}}{x_i + x_{io}}\right|\right)^{\frac{w_i}{n}}$$

The equation’s values as described by the Planetary Habitability Laboratory **(r01/08/2016)** are:

- x_i is the planetary property, for example surface temperature.
- x_{io} is the associated Earth value, for example 288 Kelvin.
- w_i is a weight exponent.

- n is the number of planetary properties.
- ESI is the similarity measure.

The weighting exponents are used to adjust the sensitivity of the scale and equalize its meaning between different properties.

This equation yields an ESI value in the range of 0.0 to 1.0. A planet is designated "earth-like" if its ESI value is 0.8 or above **(PHL r01/082016)**. Gliese 832c has an ESI value of 0.81. Our own solar system's planet Venus manages to attain a higher ESI value, of 0.9. Plainly, therefore, an ESI value of 0.8 or above is not a reliable indicator of true "earth-likeness".

In judging whether a planet is earth-like we are judging whether it is a "goldilocks body"—i.e., a body "just right" for life. Here we speak of "body" rather than a "planet" so as to leave open the possibility of life developing on moons, or asteroids, or even comets. But what exactly is a "goldilocks body"? We don't know precisely what a "goldilocks body" is but we can be either conservative or liberal in our description. On the conservation end of the spectrum we would take Earth as paradigm. This means that it must have oceans of liquid water. This in turn requires an atmosphere to prevent the water from evaporating straight into space. It also requires a magnetic field (to protect from space radiation and solar wind), which requires a spinning molten core of liquid metal. The existence of such a molten core probably implies plate tectonics and volcanic activity. For planets with a star like ours (a G-type main-sequence star (G2V)) the orbital radium must be within the habitable range of 0.723 AU (astronomical units) and 1.5 AU (which is roughly the zone between Venus and Mars). Another potential restriction is the size of the planet. A body that is very much smaller than earth, for instance of a size similar to Mars, is unlikely to retain a sufficiently dense atmosphere to maintain life. On the other hand, a body significantly larger than the Earth is likely to have an excessively dense atmosphere containing concentrations of free hydrogen and helium, which will result in chemistry and geology radically unlike that on Earth. Such planets are classified as being "mini-gas giants" or "gas dwarfs" depending on their size. According to Rogers **(2015)**, the transition point between rocky bodies and gas planets is at about 1.6 Earth-radiuses, and so the biggest a "super-earth" can be is roughly 1.6 times the size of the Earth.

What of the less conservative options? Well, if we expand consideration beyond planets in the "habitable zone" of a star we can imagine moons with oceans orbiting gas giants. An example is Jupiter's moon, Europa. It is speculated that tidal forces acting on Europa may have produced a molten core and a liquid ocean sealed off from space by a "shield" of ice. If this is correct then Europa could be a "goldilocks body". Extremophiles living in the vicinity of Earth's own deep ocean vents suggest the existence of life in such an environment is a very real possibility. It appears that Europa-like moons could well be widespread in the galaxy.

The notion of a "goldilocks body" might be pushed even further. For example, consider a planet that is tidally locked to its parent star. It will have a sun-facing side that is extremely hot, and a night-side that is extremely cold. Various mechanisms have been proposed which may increase that chances of the habitability of such planet. One is the proposed regulation of albedo and circulation of temperature via the production of clouds **(Yang et al 2013)**. Another is the circulation of heat from the sun-facing side to the night-side via oceanic circulation **(Hu & Yang 2014)**. Now, neither of these mechanisms may make the sun-facing or night-side of such a body completely habitable but in between the two uninhabitable zones might be a circular habitable zone (known as a "ring ecosystem") where the temperature is "just right" for life.

An even more bizarre possibility is that life might exist in the atmosphere of a so-called "hot Jupiter" planet (this being a gas giant that orbits relatively close to its star). If the atmosphere of this gas giant contained the right mixture of chemicals it might serve as a strange kind of ocean in which life could "float". Though it may sound incredible, respected scientists have considered the possibility. For example, Carl Sagan and his colleague E.E Salpeter **(1976)** speculated on the possibility of life in the atmosphere of Jupiter. A warmer world would surely have a greater chance to support such an ecosystem.

To summarize, the REH has not been falsified by the recent discovery of numerous so-called “earth-like planets”, since the definition of “earth-like planet” includes planets which are obviously very inhospitable to life (such as Venus). At present we simply do not know whether REH is plausible or not. Its plausibility is largely contingent on which bodies qualify as being “goldilocks bodies”. On a conservative view of what counts as being a “goldilocks body”, only planets that are very similar to Earth will qualify. If we take a liberal stance we can include a great many bodies, from icy moons, to tidally locked planets, to “hot Jupiter’s”. At present we simply don’t know which view is more plausible. “Goldilocks bodies” may be rare or they may be common, for now we can only speculate. At this stage we have no strong reason to think REH is true, or that it isn’t. Claims to the contrary are premature.

4.2. The Neocatastrophism Hypothesis

Even if a “goldilocks body” exists, there are numerous reasons why it might never harbour intelligent life. The Neocatastrophism Hypothesis proposes that life is routinely annihilated by astronomical phenomena, such as gamma ray bursts (GRBs), before it gets the chance to develop very far **(Cirković & Vukotić 2008)**. These catastrophic events, most often attributed to GRBs, act as a mechanism which has potentially prevented the development of any intelligent life our galaxy in the past **(Cirković & Vukotić 2008)**. The hypothesis also proposes a model of stellar evolution in which the frequency of these “purges” decreases over time in galaxies, as the unstable stars which cause them die out. It proposes that at some point there is a “phase shift” toward a galaxy in which these events become sufficiently rare for complex life to finally be able to develop **(Vukotic & Cirkovic 2008)**. If this hypothesis is true it could mean that humans may be the first intelligent, technological species in the galaxy.

GRB’s are thought to be produced during supernovae or hypernovae as a rapidly rotating, high mass star collapses to form either a neutron star or black-hole. They are highly energetic electro-magnetic events and the energy is focused into a jet, or beam, of gamma-rays. They are thought to have the potential to eradicate life on any planet that the beam hits, or at the very least cause a mass extinction of major proportions. The range at which such a beam can cause a mass extinction is thought to be about ten thousand light years (i.e., one tenth of the diameter of the galaxy) **(Melott et al 2004, 4)**. It appears that these events occur on average only a couple of times every million years in a galaxy in the present epoch **(Podsiadlowski et al 2004)** and as such are relatively rare. However, it is postulated that GRB events would have been far more common in the distant galactic past **(Podsiadlowski et al 2004)**. Calculations suggest that the Earth itself maybe no stranger to GRB events, and they could be expected at a rate of about one per billion years **(Melott et al 2004, 20)**. Repeated GRB exposure could prevent the emergence of more complex life, and thus intelligence, on other planets. If we consider the immense time scales that evolution works over it could be the case that many planets, including ours, have experienced these events many times over. As such if it is the case that many planets are exposed to multiple GRBs then this may account for there being very few cases where intelligence has the chance evolve. There is some evidence that the Ordovician Mass Extinct was precipitated by a GRB event **(Melott et al 2004)** and perhaps GRBs may have contributed to others **(Melott et al 2004, 20)**. What suggests that the Ordovician Mass Extinction could have been caused by a GRB is that things that lived in the deep ocean or that lived underground tended to survive, where as those that did not tended to go extinct **(Melott et al 2004, 17-19)**. With this in mind we can infer that the cataclysmic nature of such an event would not necessarily reduce life to such an extent as to inhibit the emergence of intelligence too significantly, this is due to the fact that life on our own planet appeared to recover fairly quickly after our own, possible, GRB induced mass extinction event.

The “Neocatastrophism” model is usually framed in terms of interstellar phenomena such as GRBs (**Vukotic & Cirkovic 2008)**, but could also include more local (astronomically speaking) events such as super volcanoes and asteroid impacts. These kinds of local events have been held responsible for many of the mass extinctions our planet has undergone. Most famously, the KT (Cretaceous-Tertiary) extinction which wiped out the non-avian dinosaurs approximately 65 million years ago is believed to be the result of an asteroid impact on the Yucatan peninsula which formed the Chicxulub crater **(Renne et al 2013, 684)**. The ecosystem before the impact was already highly strained due to environmental changes **(Renne et al 2013, 685)**. This strain could be associated with intense volcanism which formed the flood basalt formation called the Deccan Traps **(Renne et al 2013, 687)**.

It goes without saying that a large enough impact event could extinguish all life on the planet, but what about a large volcanic event? One of the largest extinction events, if not the largest, in the history of the Earth is associated with one of the largest volcanic events of the last 500 million years, the event which formed the Siberian Traps. This "Permian mass extinction", 250 million years ago, happened at the same time as the flood basalt eruption which lasted for one million years and produced two to three million cubic kilometres of ejecta **(Renne et al 1995, 1413)**. During the Permian extinction event 90 percent of ocean species and 70 percent of land vertebrate families went extinct **(Renne et al 1995, 1414)**. The associated climatic variations during the extinction event are what would be expected from such a massive volcanic event **(Renne et al 1995, 1415)**. It has been suggested that the global warming caused by the volcanic gases was amplified further by the ignition of coal beds by the eruptions **(Ogden & Sleep 2012)**. Others have put forward the idea that the methanogenic bacteria *Methanosarcina* population exploded. This proposed explosion is suggested to be due in large part to the sudden increase in nickel concentrations in the ocean due to the volcanic activity **(Rothman et al 2014)**. As well as the Permian extinction other extinctions have been postulated to have had large scale volcanism as either a major or contributing cause. For example, as the Triassic-Jurassic extinction is linked to the formation of the Central Atlantic Magmatic Province **(Blackburn et al 2013)**.

If most planets which develop life also have to contend with episodes of massive volcanism, as life on Earth does, then it could be the case that life, or at least complex life, is regularly killed off due to these events. This is especially the case if those planets are more volcanically volatile then our own. The likelihood of a planet which develops life being prone to volcanism is very high. This is because in order for a planet to have magnetic field it must have a spinning molten core of iron. This magnetic field protects the surface of the planet from cosmic radiation from the planets parent star, for complex life to exist on the surface of a planet this magnetic field is a requirement. Most planets would have to contend with the threat of impact events as well. These same forces could be routinely sterilizing planets, perhaps even more frequently then GRBs. Even if the likelihood of GRBs decreases overtime the threat of massive volcanism or a sufficiently large asteroid/comet will remain constant. This decreases the chance of a “phase shift” toward a galaxy abundant in complex, intelligent lifeforms.

It must also be remembered that such extreme events, which may lead to mass extinctions, are also the potential catalysts for the milestones that may be required to reach intelligence. As such these potentially life threatening events may also be required to occur, so long as they do not sterilize the planets on which they occur. Many of the diverse array of species on this planet would likely not exist if it were not for such events. The dominance of mammals on this planet, and our own existence, is very probably due to the KT mass extinction. It is hard to imagine the emergence of primates and the subsequent evolution of Hominids in a world still dominated by large theropod dinosaurs. One of the outcomes of mass extinction events is the removal of the dominant species from their habitats and the subsequent rapid radiation of different life forms into the newly opened niches in the environment. This sudden removal of species, and sometimes whole clades, from the environment creates an emptied ecology into which brand new branches of the tree of life are allowed to develop. An example is the rise and radiation of Dinosauria after the Permian Mass Extinction, Before this event the world was dominated by a diverse array of Therapsids, commonly called the Mammal-like reptiles. After the Permian Mass Extinction (which was so devastating to the tree of life it is also called The Great Dying) the world saw a rapid diversification of life, with the emergence of whole new groups of animals such as Mammals, Dinosauria, Pterosauria, and the various marine reptile groups. This type of diversification would, arguably, not have been possible without such a dramatically cataclysmic event. These types of events present new opportunities to once marginal groups of animals to fill now empty positions within the environment and to diversify and evolve in new ways. Thus Mass Extinctions on life-harbouring planets all through the galaxy may be part of what allows life to potentially develop along the path to technological intelligence, like primates were able to after the K-T mass extinction. The tension between these events being a catalyst for the development of life and also its potential destroyer leads to uncertainty in our judgement of the Neocatastrophism Hypothesis.

4.3. The (un)likelihood of Technological Intelligence

A much later step in the chain of events outlined above is the development of intelligence. Determining whether this is a probable event or not is complicated by the fact that, in order for it to be detectable, the intelligent beings in question must have the ability to make and use complex tools (by, for example, constructing von Neumann probes). To be precise, what we want to be able to estimate is the probability of intelligence not only evolving but also developing technologies that would enable us to detect them. I will call such an intelligence, that actually develops the technologies necessary to be detected over interstellar distances, a "Technological Intelligence". One way to try and approximately evaluate the probability of Technological Intelligence developing is by considering the evidence we have immediately to hand, namely life on our planet. Admittedly this is a sample of one, which doesn't provide a very statistically robust basis for extrapolation. However, it is better than nothing and it is all we have.

The evidence from Earth's geology and biology suggests that intelligence, or, at least Technological Intelligence, evolves only very rarely. In the history of life on Earth, prokaryotic life (consisting only of very simple cells) arose at least 3.5 billion years ago, while more complex and sophisticated eukaryotic cells evolved about 2 billion years ago **(Knoll et al 2006)**. Multicellular animals evolved only approximately 800 million years ago **(Erwin 2015)**. The Cambrian explosion took place 542 million years ago, and it is thought that the first complex nervous system with a "brain" developed only at around this time. Brain size seems to have increased progressively through evolutionary time as chordates have evolved as seen in the various common ancestors we share with fish, amphibians, reptiles, and mammals. However, the size of the brain often varies widely from species to species within these groups, and, there is no straightforward correlation between brain size and intelligence. (For example crows are highly intelligent animals by many metrics despite having a brain that only weighs, approximately, between ten and thirteen grams whereas cows, which are arguably less intelligent, on average have brains which weigh between 425 and 458 grams.)

There is strong evidence that no Technological Intelligence has evolved on earth before us. To see this it is useful to imagine what members of a far future Technological Intelligence would find if they conducted palaeontological studies of Earth's history. They could easily discover that we had existed because of the traces we will leave behind. These traces of our impact upon the Earth forming a distinct geological marker has caused some in the scientific community to discuss whether or not to classify a geological era distinct from the Holocene, the Anthropocene. The exact starting point of this new Anthropocene epoch is debated but a consensus of around the Industrial Revolution is being formed **(Smith & Zeder 2013)**. The geological markers of our existence include a sudden and geologically unprecedented dispersal of many plant and animal species across Earth's continents, accompanied by a mass extinction event involving numerous other species **(Dirzo et al 2014)**. It is likely that these future palaeontologists would find geological indicators of a suddenly warming planet, rapidly rising sea levels, and ocean acidification, which will together suggest that very large quantities of coal, oil and natural gases were burned . That this happened would be confirmed by noticing missing reserves of fossil fuels, along with a lot of other minerals and metals **(Steffen et al 2007, 614)**. There will be found strange clusters of fossil fuel by-products, metals and minerals all grouped together in odd geological formations (our rubbish dumps). Along with this will be traces of exotic materials which we have engineered. They may also notice odd, long and snaking formations of a peculiar rock type (which will be our roads, if they survive). If they travel to space they will be liable to find traces of our technology on the moon (which has no erosive atmospheric or geological processes operating apart from very rare meteorite strikes). They will perhaps even find some of our ancient satellites still parked in a graveyard orbit around Earth or at one of the Earth-Moon Lagrange points. These are all going to paint a clear picture of an intelligent technological species having once lived on the planet.

If we found evidence of such traces in the geological record- a Dinosaur civilization or something similar -then this would be powerful evidence that Technological Intelligences are apt to evolve with a relatively high probability on planets with complex life. But, needless to say, we don't find any such traces. The signatures that civilisation building, technological species would leave behind appear to be absent from Earth's geological record. This being so it would appear that we are first such species to evolve on Earth in all the billions of years life has inhabited it.

When we are using the example of Earth to estimate the probability of Technological Intelligence evolving on other planets, we should take into account not only our own existence, as the sole technologically capable species to evolve thus far on Earth, but also the existence of species such as Dolphins, Chimpanzees, and Crows, which are relatively intelligent despite *not* being technologically capable. After all, it might appear that species like Dolphins and Crows, relatively intelligent as they are, are not *too many steps* away from becoming technologically capable themselves. Unfortunately confirming that an animal is semi-intelligent, self-aware or has human-like intelligence is open to debate. The evidence from animal intelligence tests is often controversial. Examples of tests to ascertain the level of intelligence in certain animal species include tool-use tests and the mirror test. The results produced by these tests of are often open to criticisms, such as the influence of bias on the part of those running the test. Lineweaver **(2008)**, among others, argues that the evolution of human-like intelligence could be an improbable rarity in the universe. One of the most important features of this discussion on the evidence of intelligence is whether or not an animal's inner-world can actually be examined. This is an old, old problem in Philosophy. However, for the purposes of this thesis, it is clear that no other species on Earth at present is intelligent in the way that is relevant. The bar is a high one involving the building of von Neumann machines and radio transmitters. So far, Homo sapiens is the only species we know of which constructs complex tools.

One reason why intelligence might be thought to be a common phenomenon in the universe is because of the popular assumption that life inevitably becomes smarter over evolutionary time, so that all life in the galaxy will eventually become intelligent. This assumption is familiar from science fiction which commonly depicts the galaxy as being full of intelligent aliens. However, we have no evidence for the truth of this assumption. The manufacturing of stone tools by early hominids about two and a half million years ago is the first real evidence of complex intelligence in the fossil record. Of all the myriad species that have evolved on Earth during its history, only a small handful of them have appeared to develop intelligence and of them only a small subset of hominids (perhaps only Denisovans, Neanderthals and Homo Sapiens) appear to have developed some level of Technological Intelligence. This itself appears to invalidate the assumption that life evolves inevitably toward intelligence. Intelligence appears to be a random evolutionary adaptation, a rather successful if perhaps expensive one, which was favoured and so became further expanded over time. However, this is true of all evolutionary adaptations. One might just as well say that it is evolutionarily inevitable for creatures to become aquatic (as with whales and seals) or to develop winged flight (birds and bats). In the case of humans, intelligence became a primary source of adaptive advantage, but at considerable expense in terms of energy expenditure (the human brain being a large energy hungry organ). When compared to our closest ancestors the total energy expenditure of Homo Sapiens is approximately 400 more kilo-calories (kcal) a day than Chimpanzees and Bonobos, 635 more kcal a day than Gorillas and 820 kcal a day than Orangutans **(Pontzer et al 2016)**. Lineweaver **(2008)** critiques the assumption that there is an "intelligence niche" and that many alien species will naturally fill this niche. If there were such a niche why did it only get filled extremely recently (evolutionarily speaking) on Earth? Lineweaver's answer, and I think that it is the correct one, is that no such niche exists. Intelligence is obviously a very useful tool for survival for creatures who live in rapidly changing environments or for creatures who are "adaptive scavengers" (who are poised to exploit any new opportunities that might appear). But it also appears to both be a very expensive tool and a tool of such great complexity that it might be very unlikely to evolve through a process of random genetic tinkering.

If intelligence is a survival strategy, and very successful one, would it not also be developed independently in other lifeforms on Earth? We have examples of similar survival strategies and adaptations being developed independently in different species, in what is termed convergent evolution. Replicated survival strategies can be seen in Seals and Cetaceans evolving aquatic lifestyles, similarly in the development of the ants' and termites incredibly complex forms of eusociality. This also occurs in the fossil record with various species of marine reptiles, in particular Ichthyosaurs very closely resembling dolphins. The evolution of flight has also occurred multiple times in the fossil record in particular the Pterosaurs adaptation to flight very much resembles that of bats. This brings up the question of the development of complex intelligence and whether this evolutionary strategy is also convergent and has developed before.

There is strong evidence that Technological Intelligences have never evolved on Earth before humans emerged. We know that human-like intelligence is expensive in terms of energy required and we know that human-like intelligence requires a very complex a set of biological adaptations in order to occur. It maybe that hominids were the first species on Earth to attempt this particular adaptive strategy. It appears that this is probably is the case. It might also be that hominids were the first to attempt this adaptive strategy in the galaxy. We must keep in mind that technological intelligence is not the *most* successful evolutionary strategy and it appears to require various radical bodily adaptations to facilitate it, such as a prehensile organ (in hominids these are hands) which allows for fine manipulation of the world in order to allow to creation and use of complex tools. Within the genus Homo the evolution of higher intelligence and the expansion of the brain required an enlargement of the skull, and a by-product of this was more difficult births. This type of modification to facilitate increasing intelligence is by no means a certainty, as brain size does not directly correlate to intelligence, but it is a factor to consider. As such Technological Intelligence may require a specific set of circumstances in order to be viable. The history of life on Earth appears to demonstrate that Technological Intelligence have a low probability of evolving. We still do not have a complete understanding of how human-like intelligence evolves, and this prevents us from making any conclusive statements. Despite this, we can tentatively say that the emergence of complex technological intelligence appears to be an unlikely evolutionary event.

4.4. Uncertainties

There are many uncertainties which prevent us from considering any of the above solutions conclusively resolved. Each of the potential steps in development of a Technologically Intelligent species may require a complex set of circumstances in order to occur. For instance, the development of complex life as we understand it followed the period known as Snowball Earth about 650 million years ago **(Hoffman 1998, 1342)**. During this period the Earth is thought to have been nearly entirely encased in ice thus putting great strain on the kind of ecology which had previously developed. This kind of environmental pressure may be required to spur the advancement of life into the steps listed above. If this is the case then it might be rare for such steps to take place. They may require a planet which is simultaneously climatically stable enough to be suited to life but that also experiences brief periods of instability and fluctuations in climate conditions. Whether this type of planet is rare or common is uncertain as is whether this is what is required for such milestones to be crossed. On Earth there does seem to be some correlation between such events and situations and the crossing of such milestones, such as with the evolution of complex life and the Neoproterozoic (1,000 - 541 million years ago) ice ages and the development of animals **(Maruyama &Santosh 2008)** and the rapid diversification and development of new species after mass extinctions **(Jablonski 2001, 5395)**. The emergence of hominids is closely associated with climatic instability **(Smithsonian... 2016)**, the evolutionary pressure this caused is likely to have adaptive significance in the evolution of hominids **(Potts 1998)**. Though these types of events are correlated with the achievement of milestones they are not necessarily causal. We also don't know how representative terrestrial life is with respect to other life.

4.5. A theistic solution?

The above dealt with various scientifically-framed First Great Filter arguments. The final version of the First Great Filter I will consider is a theistic, rather than scientific, version. The idea is a very simple one, namely that the universe was created only for humanity, and thus that mankind was a unique creation by God. The idea comes, of course, from the Old Testament and other Middle Eastern religious texts, especially those which claim that "God created man in His own image". The implication is that humanity is special, our existence being the *raison d'etre* for the universe as a whole. A natural further implication is that no other Technological Intelligences exist.

Before we dive deeper into this theory we must understand that this is not by any means universally supported by all religions, and is not even endorsed by all Abrahamic groups. An example is the Catholic church, the largest Christian denomination in the world. The Pope himself stated in 2014 that he would welcome aliens and would be willing to have them baptized **(Dias, 2014)**. The Vatican astronomer, Fr. Funes, has claimed God could create multiple types of intelligent beings throughout the universe, writing that "we cannot put a limit on God's creative freedom" and that these would all be "part of creation" **(Popham 2008)**. Fr. Funes also states that the Bible itself cannot be understood literally as "it is not a book of science" **(Popham 2008)**. Even as early as the medieval period many Christian thinkers considered the idea of multiple creations. A notable example was the Franciscan friar William of Ockham (1287 – 1347) who stated that God, in his view "could produce infinite kinds" and was "not limited to making them in this world" **(Siegfried 2016)**. Nicholas of Cusa (1401-1464) was a little more direct in his assessment of the possibility of God creating multiple populated worlds, claiming that space had no centre and that this meant that Earth had no privileged claim to be a sole creation with respect to life **(Siegfried 2016)**. He claimed that "Life as it exists here on Earth… is to be found, let us suppose, in a higher form in the solar and stellar regions". He then speaks of these extra-terrestrial lifeforms "all owing their origin to God, who is the centre … of all stellar regions" **(Peters, 1995)**. Furthermore, Nicholas of Cusa was not the only Pre-Copernican who was amenable to the idea of multiple creations. Others include the likes of Magnus, John Major and da Vinci **(Peters, 1995)**.

In short, religious thinkers have a long history of accepting the idea of there being intelligent extraterrestrial life in universe outside of Earth. With this understood we can now look at the opposing religious idea, that God would not create other intelligences and that this is why there is the Silent Sky.

If we look at the evidence we currently have at hand we can make two observations about the universe. First off, we have not been contacted by alien intelligences nor do we have any direct evidence for the existence of such intelligences. Secondly, there are a number of apparently unlikely circumstances that make the Earth habitable for life (and intelligent life). With this knowledge it is not unreasonable to conclude that there is something special about the Earth and its place within the galaxy. An easy response to the Fermi-Hart paradox is to claim that the Earth is alone within the universe in terms of hosting intelligence, and it's certainly the case that one possible explanation for this is because we are unique due to being the subject of divine creation. However, to concede that this is a *possible explanation* is, of course, not to say that it is a *good explanation* or the *best explanation*, objectively speaking.

Of course, for those who are antecedently committed to the existence of a creator deity, it will be a very attractive option. But for others it will be a very big bullet to bite. Atheists will reject it on the basis of any number of well-known anti-theistic arguments (such as the argument from evil) which will not be addressed here. Even some theists, those who are scientifically minded, might be loth to endorse it due to a reluctance to give their religious beliefs a central role in explaining observable phenomena.

This is not to say that the theistic solution is flatly untenable, but it is to say that atheists and scientifically minded theists will be reluctant to endorse it if other, more robustly scientific options are available. I have already mentioned several such more scientific solutions (including the other variations of the First Great Filter arguments, the Transcension Hypothesis, and the Zoo Hypotheses) and more will be described below.

Chapter 5: The Second Great Filter

To believe in the so-called Second Great Filter is to believe that technological civilisations typically don't last very long and either destroy themselves or get destroyed before they have had any significant opportunity to advertise their existence to the rest of the universe. When framed in terms of the Drake equation the idea is that the values of F_c (the fraction of intelligent species which produce a technological civilisation who are detectable) or L (the length of time that civilisations are detectable) are low.

Civilisations will conceivably be highly resistant to being destroyed once they have left their home planets and begin to colonize other worlds. This is because they won't have "all their eggs in one basket". For this reason, formulations of the second great filter which claim the civilisations tend to destroy themselves *before expanding beyond their planetary home* are the most plausible.

Why might civilisations destroy themselves? There are many possible mechanisms from environmental to technological **(Bostrom 2002)**. Possible mechanisms include nuclear weapons, civilisation-induced climate change, and biological weapons which get out of control. Various future technologies like nano-bot weapons and rogue AI are also things which a civilisation could unleash on to itself with cataclysmic results. Bill Joy, in his article "Why the Future Doesn't Need Us" **(Joy 2000)**, outlined various possible reasons why the technologies of genetic engineering, nanotechnology and robotics (GNR) could lead to self-induced human extinction. Joy proposed that rather than GNR technologies giving rise to the transhumanist utopia that is often imagined, they could instead represent a terrible risk of annihilation. There are various reasons for a technological civilisation to produce an innovation in any of these GNR fields and subsequently end up destroying itself inadvertently (opening a technological "Pandora's box", so to speak). It is quite likely that such technologies would be developed for positive reasons, but would unfortunately result in severely negative outcomes for their creators. A particularly infamous scenario is the possibility of a "grey goo event", whereby nano machines end up out of the control of those who first designed them and replicate exponentially thus destroying the biosphere of the planet. This hypothetical scenario demonstrates that the danger of nano-bots is in the self-replication aspect of the technology **(Joy 2000)**. The likelihood of a “grey goo” scenario is debated and is highly speculative at this point.

Another, seemingly more feasible possibility is a rogue AI—this being an artificial intelligence which, decides, for whatever reason an AI might have, that its creators should or must be destroyed. The AI might not even have to destroy its creators. It might simply overtake them in all things and ignore them. This AI would simply take control of all the societies’ systems and leave its creators in a pseudo-dark age. Either way the technological civilisation of its creators would be destroyed. The possibility of a potentially dangerous AI is particularly worrying from the human perspective because our own technological civilisation is already inextricably underpinned by advanced computer systems and their associated programs. If (or when) we develop a true AI it would easily have access to every important utility and system within our society. There is a non-zero probability that this AI would be hostile or indifferent to our own existence, in this case it could rapidly disable all these systems. Of course it needn’t be an instantaneous machine apocalypse either. Joy **(2000)** references the Unabomber when describing an indifferent AI scenario, suggesting that the creators might simply slowly hand over control to the much more intelligent machines as the systems become more complex, or do this seeking to liberate themselves from mundane work. The artificial intelligences have no inherent hostility, but merely perceive the great mass of their creators as an unnecessary burden upon the system, an inefficiency. Much has been made about developing AI to be benevolent. Safeguards aimed at avoiding actively hostile or indifferent AI have been proposed, such as creating hard coded protections which guarantee the machine-intelligence will not turn against us. Whether this is truly possible or not is an open question. The alternative is to become, in a sense, one with the machine intelligences. This is covered in the Transcension Hypothesis chapter above. I would argue that in this case the original creator species is also destroyed, and replaced by the new pseudo-hybrid intelligence.

Before either the nano technologies or the artificial intelligences get a chance to eliminate the human species genetically engineered threats might do it first. Humans have developed fully functioning genetic engineering first out the three GNR technologies. Whether this occurs universally for Technological Intelligences is, unfortunately, unknown. What we do know is that genetic engineering opens the door for some truly apocalyptic scenarios— for instance, the advent of a White Plague, a fully engineered plague with the ability to kill all humans on the planet **(Joy 2000)**. The dangers with genetic engineering are not just confined to super-plagues but also extend to lifeforms created to improve our lives. These are the genetically engineered crops, animals, and micro-organisms. Such a creation might have devastating effects upon ecosystems and the biosphere through unforeseen interactions. This could be due to the engineered species out competing the "natural" species themselves, or they could interbreed with existing species and create hybrids which destabilizes the ecosystem. Either of these scenarios results in a devastated biosphere.

Why should we think such a filter operates? One reason is what we know about ourselves. We know we are responsible for large scale environmental destruction which has destabilised many ecosystems around the globe. We also know we are responsible for climate change which could be in and of itself cataclysmic in its results. We also know that humans have a large enough stockpile of nuclear weapons to potentially wipe ourselves out. And we know that human history contains many examples of civilisations which have destroyed themselves by compromising the environments on which they depend, such as the Maya and the Easter Island civilization. The Second Great Filter appears to be very plausible when we consider how our own civilisation(s) have progressed.

Why do the facts we know about our own species suggest the operation of a Second Great Filter? There are two main reasons.

5.1. Civilization's impacts on the environment

Human societies, at least those which we would consider "successful", tend toward an exploitation relationship with regards to their environments. This is the primary reason behind the growth of civilisations but it also damages those environments. As humanity has advanced technologically this has only caused larger damage. Now humans are fundamentally changing our planet's climate due to our activities **(IPCC 2014)**. This relationship with our environment has influenced the way we construct our economies and societies. It has led to an advanced technological society but it has also caused severe damage to our planet, and this appears unlikely to change any time soon. There are a variety of environmental factors which have the possibility to reduce the viability of our technological civilisation in the long run. These include the loss of farmland due to pollution and soil degradation, ecosystem destruction caused by exploitation for resources, atmospheric pollution and climate change due to human industrial activity **(Milman 2015)**, and the over-exploitation of water resources. Climate change, as the most global of environmental threats, poses a number of serious risks to the continued viability of our technological civilisation, particularly if there is no or limited effort to mitigate the negative long-term impacts. In just the next fifty years it is projected that food production will decrease due to increased aridity and changes in weather patterns, which will result in a large increase in under-nutrition **(Smith et al 2014)**. Along with this will be a rise in extreme weather events, which are likely to strike high population areas. These extreme weather events will take the form of stronger storms, more intense droughts and heat waves, and catastrophic flooding, among other effects **(Smith et al 2014)**. The ability of our current world governments and economies to be able to respond effectively as these become regular events is unknown, and not guaranteed. Not only will these events constitute a serious burden on our technological civilisation, perhaps beyond its capacity to deal with, but humanity will have to deal with the loss of many established and key centres of population as the sea level rises due melting ice and thermal expansion. Much of humanity's vital production and economic centres are located in areas which are extremely vulnerable to the projected rises in sea-level, such as on shore lines and in delta regions. The loss of such major economic and civic hubs is likely to compound the ongoing climate-change-caused system stresses of the loss of arable land and the creation of large numbers of climate-change refugees. The scale of the damage that climate change is likely to cause is going to be determined by our response to it. A strong attempt to mitigate our greenhouse gas emissions is obviously likely to result in a more positive, survivable outcome, whereas a business-as-usual response is likely to result in disaster and civilisation's collapse due to overwhelming, compounding events.

A particularly stark example of the results of human activities' effects on the environment is coral reefs dying all across the planet. Coral reefs contain much of the oceans' biodiversity. There are various ways by which our technological civilisation drives this die-off of coral reefs. For instance, pollution has devastating results for corals and is a primary cause of the degradation of reefs **(NOAA n.d)**. This pollution can take the form of agricultural run-off, sewage and other nutrient-rich material. The by-products of this influx are decreased oxygen content in the waters around reefs and a boom in algal populations. The result of these by-products is that the corals die, out competed by the algae, and the ecosystem's biodiversity significantly reduced due to much of the animal life being unable to survive on the reef anymore. Ocean acidification is also a major threat to corals due to their calcium carbonate skeletons, which they excrete to build the massive reef structures we see. Ocean acidification is primarily due to man-made carbon dioxide build-up in the atmosphere, whereby the oceans act as a carbon sink and absorb much of this atmospheric carbon dioxide. This absorbed carbon dioxide reacts with water and converts into carbonic acid thus decreasing the pH value of the ocean overtime. The more acidic the oceans become the harder it is for coral to grow their skeletons as calcium carbonate becomes under-saturated in the oceans, and maintaining existing exposed calcium carbonate skeletons becomes harder **(Orr et al 2005, 681)**. From 1751 to 2004 the pH levels of the ocean has dropped from 8.25 to 8.14 and is projected to fall further to 7.85 in 2100 **(Jacobson 2005)**. Admittedly ocean acidification has much broader impacts then just adversely effecting corals. All marine lifeforms which build their skeletons with calcium carbonate are and will be negatively impacted by continued acidification of the ocean. The most fundamental organisms in the oceans' food chain, pteropods and plankton, will be significantly affected **(Orr et al 2005, 685)**. If this were to occur the ecosystem of the oceans would be disastrously effected, and could cause a cascade of extinctions all the way up the oceans' food chains. A survey conducted in 2008 revealed that many of the world's reefs were under significant pressure, concluding that nineteen percent of the worlds reefs were already lost, and a further twenty percent would likely be lost in the next ten to twenty years **(Wilkinson 2008, 5)**. A 2011 report by the World Resources Institute projected that by 2050 all the reefs around the world would be at risk of being lost due to human activities **(Burke et al 2011)**.

The subjects mentioned above are all imminent threats but are also intrinsic results of human technological civilisation. In trying to anticipate whether our own, and extraterrestrial, technological civilisations can mitigate these threats which they have created, it is necessary to consider how these threats were created in the first place and in particular whether it is somehow an intrinsic part of intelligent organisms' nature to create the situations liable to lead to their own destruction. This topic will be elaborated on in the following sections.

5.2. Our warlike nature

Humans tend to have an inclination toward mass violence. This takes many forms but obviously its most common and serious form is war. Humans have developed all sorts of ingenious methods of prosecuting these wars throughout the course of our history. These range from the strategies of how to beat one's opponents to the weapons used. The fascination with war and militarism has not diminished as human civilisations have advanced technologically. Usually the most dominant societies on the planet at any time are the ones who have the largest or most powerful military capabilities. Human technological advances can often be traced back to military or warfare needs. Two good examples are the computer and the internet, arguably the most important innovations of our time. The computer emerged from the British war effort during World War Two, and the internet was developed by the United States military. This is not to say all technological advances are due to humanity's more bloodthirsty predilections, but is merely to highlight how intrinsic those activities are to our current civilisation and its technological innovations. This violent streak in humanity has led to the invention of a number of apocalyptic weapons. These include nuclear weapons, biological weapons and chemical weapons. A war on the scale of the first or second world war could see the use of any number of these weapons which could, and probably would, have terrifying consequences for human civilisation.

Humanity has also embraced a type of societal and economic organisation which tends to exacerbate these problems. The mechanism by which humanity has advanced so very quickly has also provided a great hurdle to slowing down our consumption of resources and thus slowing down environmental and climate damage. The continuation of this could likely result in more conflict as people live in more deprived conditions. It is a fundamental component to our economic system, and which is becoming more and more global, that expansion and growth must continue, in order to do this, we must consume more resources at a greater rate.

There is another prospect to consider and that is if humanity is truly representative of all truly intelligent lifeforms. Humans appear to be a species with predisposition toward greed, competition and violence, at least on a societal level. Hominids have a long history of violence and it has been pointed out in many studies on the subject of violence that even early hominids show signs of interpersonal violence, often using weapons **(McCall & Shields 2008, 6)**. Violence also appears to be ubiquitous across all the various types of human societies **(McCall & Shields 2008, 9)**. It has been suggested that the development of agricultural societies is the attributable cause of large scale homicidal activity within human groups, but evidence suggests that these forms of violence are much deeper **(Walker 2001, 586)**. Bones collected from Mesolithic sites show evidence of groups of humans who were bludgeoned and decapitated, seemingly together **(Walker 2001, 586-587)**. These finds demonstrate that even societies which haven't developed agriculture still do conduct such acts. There are some theories for the reason that aggressive behaviour has developed within humans. Buss and Shackelford **(1997)** propose seven adaptive problems that aggressive behaviour may have evolved as a response to. These are:

Co-opting the resources of others.
Defending against attack.
Inflicting costs on same-sex rivals.
Negotiating status and power hierarchies.
Deterring rivals from future aggression.

Deterring mates from sexual infidelity.

Reducing resources expended on genetically unrelated children.

Of course, there could be many others and these seven could easily work together to produce a favourable evolutionary advantage for aggressive behaviours. Buss and Shackelford **(1997)** proposed these as possible evolutionary psychological candidate solutions to the phenomena of aggressive behaviour in humans.

Historically it appears that a great many of the most successful, and less successful, human societies demonstrated these aggressive traits. This could be because humans evolved to intelligence in an incredibly harsh and changeable environment. It is easy to imagine how intelligence could be a useful adaptation in an environment that was constantly fluctuating and where uncertainty was the daily routine. The environment during the period of hominid evolution was one of constant flux and routinely alternated between extremes **(Smithsonian... 2016)**.

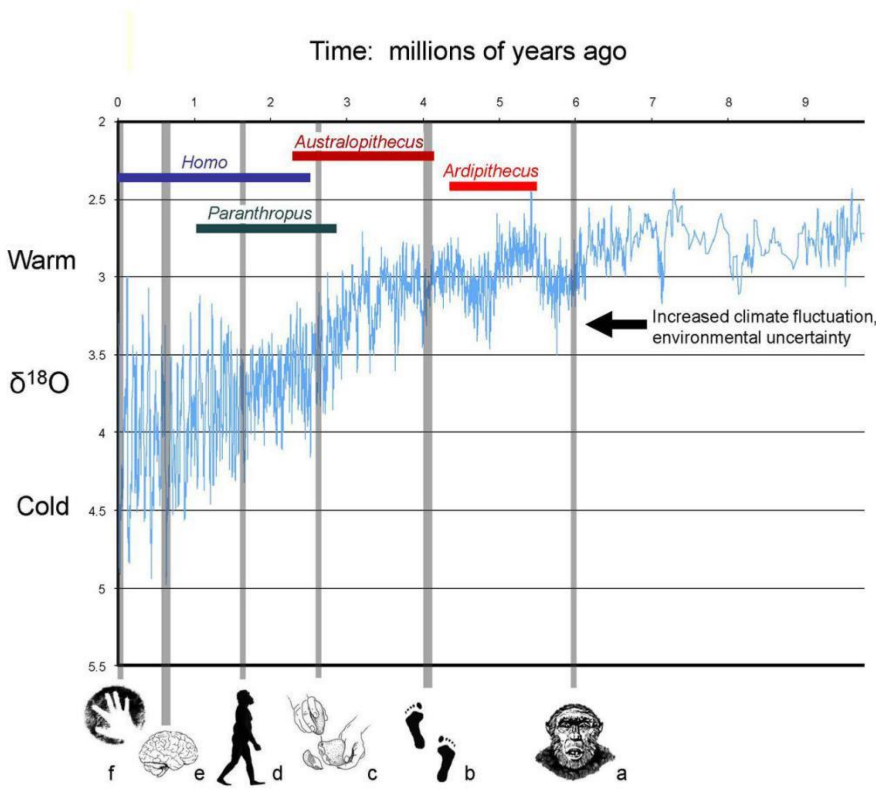

Figure 1. Oxygen isotope (δ180) curve for the last 10million years (Smithsonian, 2016)

This kind of environmental pressure could account for our large brains and ability to live everywhere on Earth, but it could also account for our less desirable behaviours such as greed, competitiveness and violence. Such behaviours would be advantageous in an environment which could produce long lasting periods of abnormal scarcity. If these coincide with the development of intelligence, then the creatures which have such traits would easily out-compete their more docile kin. This is even more advantageous when expanded to group level where more aggressive and greedy groups could easily out compete those groups which were not. It has been discovered that our closest living relatives, Chimpanzees, demonstrate lethal intergroup violence and that this kind of behaviour is characteristic of the species **(Kelly 2005, 15294)**. Early hominids also have signs of this kind of intergroup violence **(Kelly 2005 & Walker 2001)**. The factors that are most likely to initiate this kind of intergroup and organised violence are limited resources and border tensions between groups. This is held in common between chimpanzees and humans **(Kelly 2005, 15295)**. These aggressive behaviours and reactions are largely responsible for those threats which produce the Second Great Filter. In this way the evolution of intelligence could produce its own limiter.

The exact reason for the evolution of intelligence, especially the kind which develops technology, is as yet mostly unknown. If extraterrestrial intelligences evolved in a similar chaotic and harsh environment as hominids it could be expected that they would have similar behaviours. The question is, should we expect all intelligences to evolve in such environments and develop these same behaviours? If so then the Second Great Filter is a compelling response to the Fermi-Hart paradox.

It may be argued that it is illegitimate to draw a general conclusion about tendency intelligence species to wipe themselves out based on the known behaviour of just one case, homo sapiens sapiens. Unfortunately, as noted earlier, humans are the only intelligent technological species we know of, and thus the only example we can draw on. Despite this we can rationally suggest that we should expect to be statistically average. As such we should expect to exhibit similar traits as other intelligent species. But the question remains:

are humans an average species compared with other intelligent species or are we a particularly violent and destructive outlier? We cannot know as of now.

5.3. Selfishness and Altruism.

Further reasons can be adduced for thinking a Second Great Filter operates, in addition to the human proclivity for self-destruction. Evolution rarely produces genuinely altruistic individuals. The reasons are well understood in that evolution promotes the reproduction of traits that benefit the organism, or at the very least their genes, and eliminates traits which are direct negatives to the survival of the organism and their genes. This rules out any behaviours which do this, and “true” altruism is such a behaviour. Altruistic behaviours are not evolutionarily stable as they are prone to being exploited by “cheaters”, those in the community who will benefit from the altruistic behaviours of others without performing any of those behaviours themselves. The Stanford Encyclopedia of Philosophy **(2016)** describes a behaviour as altruistic “when it is motivated by a desire to benefit someone other than oneself for that person’s sake”. On the other hand, biological definitions of altruism involve the concept of reproductive fitness such that an act is considered altruistic if the act assists the actor at a cost to its overall reproductive fitness. In this way biological models for altruism do not exactly match everyday definitions of altruism. The reason that this biological definition of altruism dramatically departs from a human understanding is in large part because most animals are considered to be non-conscious and thus we don’t know if they “want” to do these acts or are driven entirely by instinct, though the same could be said for humans. An extreme example of this would be ants, or any eusocial insects, in which the vast majority of the species are sterile and serve the queens of their colonies at the total expense of their own reproductive fitness. Explanations for these types of altruistic behaviours have been given over the years. Eusocial insects are an extreme example of kin selection, in which an individual might sacrifice their own reproductive fitness for the sake of closely related individuals. It is easy to see why this behaviour might evolve, as the genes responsible will be allowed to continue to propagate and could out compete those members of the species who do not have this behaviour, especially in species who have group behaviours and are social animals. In this way behaviours brought on by kin selection are not a truly altruistic, and are instead selfish behaviours especially on the part of the genes.

Where animals do not perform altruistic acts solely for individuals with whom they are closely related another explanation is required. Reciprocal altruism, as defined by Trivers **(1971)**, is the idea that individuals perform altruistic acts in the expectation that they will be rewarded at a later time in return. Within the model of evolution by natural selection it is illogical that altruistic acts are performed unless the individual engaged in these altruistic behaviours was being rewarded in some way. One problem with the reciprocal altruism model is that an effective strategy is to “cheat”, to receive the altruistic act yourself but then not reciprocate. This kind of strategy is viable if the individual does not expect to interact with the altruist in the future, because you may instead be punished if you encounter them in the future. As such this form of altruistic behaviour may be more likely in species which live in groups and are more socially orientated, much like humans. Trivers **(1971, 47-48)** points out that reciprocal altruism might be an effective explanation for altruistic behaviours in humans, especially given the strong history of the notion of reciprocation within human societies. It is easy to see that expecting a reward, or at the very least a favour returned, is not exactly what many would see as genuine altruism. It is also quite understandable why true altruism would not be a favourable behaviour to develop within a species given the nature of evolution. There must be something about the behaviour which rewards either the individual, genes, or group in order for it to be selected for and thus passed on to the next generation. In this way these behaviours can be seen as self-centred altruism in that it is altruistic but only up to the point that it benefits the one doing the behaviour, whether the individual, their genes, or their group/species.

Any extraterrestrial technologically intelligent species is going to have to have been the result of natural selection, and thus will be subject to its tendency to favour selfish behaviours. We have seen that even if a behaviour appears to initially be altruistic it is likely that it will have a underlying selfish reason for existing due to natural selection being unfavourable to purely altruistic behaviours, such that a species will be prone to exhibit selfish tendencies. These tendencies brought up to the level of technological societies could have extremely disastrous consequences for these species. Greed, war and apathy on a macro-level are already problems at the root of many of humanities’ own long-term threats, such as climate change and resource depletion. Whereas greed, aggressive behaviours, and apathy toward those that cannot directly assist you are positive survival traits in a Darwinian world like the wild savannah 250 000 years ago, within our complex technological civilisation they can have severely negative outcomes. If these are universal in all species, due to being evolutionarily favoured behaviours, then it is likely that similar problems occur within all technological intelligences and as such the Second Great Filter is a highly probable solution.

Chapter 6: Are they here?

One technically valid approach to the problem of explaining why there are no signs of alien life here on Earth is to simply deny the explanandum, by asserting that the aliens in fact *are here*, already living on Earth, or, at the very least, regularly visiting our planet. If this is true then we have no Fermi-Hart paradox, and the answer to the question, "Why aren't they here?" is simply, "But they are here!"

I will call this proposed solution to the Fermi-Hart paradox the "X-Files solution". The main proponents of this theory are so-called "Ufologists". These are people who investigate claims of UFO activity either on Earth or, sometimes, in space near Earth (such as "sightings" on NASA feeds). More generally they promote the theory that UFO sightings and related phenomena are evidence that aliens are operating and active on Earth. The kind of investigations that Ufologists do are often criticised as being unscientific and biased. The evidence they cite, such as it is, consists of:

1. Hundreds of thousands of reported sightings of UFOs.
2. Many thousands of reports of alien abductions.
3. Historical monuments and structures on Earth that purportedly could not have been built by the people of the time.
4. Mysterious formations on other planets, and mysterious celestial objects.

I will give the X-files solution relatively short shrift, since the evidence backing it up is notoriously flimsy. I will begin by discussing several especially famous UFO sightings, and by explaining why they are not deemed credible by the academic mainstream.

6.1. Proposed cases of UFO activity

The first popularized sighting of a UFO took place on the 24th of June 1947. A pilot by the name of Kenneth Arnold was flying over Mount Rainier in the USA when he reported sighting nine craft he described as having the shape of flat plates **(Sagan 1997, 70)**. The media used the term "flying saucers" to describe these UFOs, and the term quickly came into common usage. The United States Air Force claims that all Arnold saw that day was a mirage. Before the Arnold sighting many airmen during the Second World War claimed to have seen small balls of light trailing their planes, keeping pace with them and sometimes passing them. These balls of light were termed “Foo Fighters”. Many Ufologists claim these balls of light were alien spacecraft although at the time many of the airmen believed the “Foo Fighters” to be a secret weapon built by the enemy. It appears likely that they were instead simply electromagnetic and electrostatic phenomena, similar to ball lightning **(Stenhoff 1999, 112)**.

More recent UFO cases are equally, if not more, dubious, where the alien nature of their origin is concerned. Possibly the most famous of the more recent UFO events is that of the “Phoenix lights”. On the night of the 13th of March 1997 two sets of lights were seen over a period of some hours starting at around 8:30pm **(McGaha & Nickell 2015)**. The first set of lights were described as forming a V pattern and as moving in a generally south easterly direction across the state of Arizona, leading some to suggest that it was a huge V-shaped craft of some kind. The second set of lights were stationary. These stationary lights were later confirmed to be nothing more than flares fired as part of a military training exercise **(McGaha & Nickell 2015)**. The first, more interesting lights were described as part of a massive otherwise dark craft because witnesses believed that they saw stars being occluded by the craft as it passed overhead. However, given that the second set of lights were caused by a military training exercise it seems probable that the first lights could instead have come from military aircraft flying in delta formation. (There is a major air force base in Tucson in Southern Arizona). Moreover, there is a well-known optical illusion that makes individual planes flying in formation appear to be a single very large craft in the shape of that formation **(McGaha & Nickell 2015)**.

Despite a few large-scale events, such as the Phoenix lights, that are witnessed by many people (so called, “mass sightings”) most UFO sightings are by either one person or a small group of people. Some of these smaller events verge on the fantastical, with the witness or witnesses claiming to have been flown around the universe or to have had prophetic visions. Without any evidence the more fantastical tales can be dismissed (since extraordinary claims do, after all, require extraordinary evidence). Theoretically they could be true, but it is much more likely they are not. More reasonable claims of merely observing a UFO are not as easily dismissed without alternative explanations. However alternative explanations- which involve things like terrestrial aircraft (like the SR-71 Blackbird in the 60's and 70's), weather balloons, Chinese lanterns, and meteorological phenomena- are usually easy to come by. The field of Ufology is heavily reliant on evidence consisting of eyewitness testimony and low-quality photographs and video, all of which are notoriously untrustworthy.

The popularity of Ufology has prompted many more sceptically minded people to investigate the claims made by Ufologists. The Committee for Skeptical Inquiry (CSI) is a group dedicated to investigating suspected pseudo-science. Famous members of CSI include Neil deGrasse Tyson, Seth Shostak, Richard Dawkins and the magician James Randi. CSI is not limited to investigating UFO sightings but has published many articles criticizing the way in which Ufologists go about investigating evidence and drawing conclusions.

One of the cases tackled by CSI is the "Valentich disappearance", which was investigated by James McGaha and Joe Nickell **(McGaha & Nickell 2013)**. This event occurred during a light airplane flight over Victoria, Australia in 1978, after sunset. The pilot, Valentich, reported to ground control that he had observed a large aircraft over him. According to the description he gave to ground control, the craft had bright lights, it was shiny and metallic, and of a "long shape" **(McGaha & Nickell 2013)**. Ground control could not confirm the existence of this craft with radar **(McGaha & Nickell 2013)**. Velentich and his aircraft subsequently disappeared without trace. McGaha and Nickell contend that Valentich was not a very good pilot, and was only authorized to fly during "visual meteorological conditions" **(McGaha & Nickell 2013)**. He had previously failed to pass commercial flight exams on multiple occasions. He had twice been cited for flying blindly, and was under threat of prosecution as a result. He had also strayed into restricted airspace **(McGaha & Nickell 2013)**. Valentich had reported another UFO sighting before his disappearance, and may have been flying that night in the hopes of seeing a UFO, as his stated reasons for flying could not be verified **(McGaha & Nickell 2013)**. The “UFO” he claimed to have seen might have just been Venus, Mars, or some other bright celestial object **(McGaha and Nickell 2013)**. McGaha and Nickell hypothesise that Valentich was simply distracted by his believed sighting of a UFO and then, because of his inexperience as a pilot, crashed.

This is just one of the numerous examples of alleged alien sightings analysed and debunked by CSI. The success that CSI has had in producing plausible explanations for apparent UFO and alien activity suggests that much of the field of Ufology is without an adequate evidentiary basis.

6.2. Alien Abduction.

Alien abduction cases are another line of evidence used to support the X-Files solution. To get an understanding of this kind of evidence I will describe one of the first, and perhaps most well-known, cases of alien abduction— namely, the Betty and Barney Hill abduction which occurred in New Hampshire in 1961 (referred to hereafter as the “Hill abduction”). It began with a claimed close encounter with a UFO which allegedly induced a period of “missing time”. This is a term used to describe amnesia occurring after the sighting of a UFO or other supposed alien experience, which prevents the person from recalling some of what happened. The UFO encounter was followed by terrifying nightmares and a visit to a psychiatrist who hypnotized the couple and recovered apparent “lost memories”. These “lost memories” allegedly show that the Hills were abducted by alien visitors who conducted elaborate “medical” tests and experiments on them. The Hill abduction is paradigm case of an alien abduction to the extent that such abductions typically consist of an initial terrifying event, followed by amnesia, then by hypnosis, and then by “memory recovery”.

Robert Sheaffer, writing for CSI, points out that much of the evidence which is claimed to support the Hill abduction is flimsy in the extreme **(Sheaffer 2007)**. For example, a “star map”, supposedly seen during the alien abduction, was reproduced by one of the Hill’s afterwards (see Figure 1). Sheaffer contends that no known constellation of stars matches the star map perfectly, and there is no agreement among Ufologists as to which constellation the star map is supposed to be a map of. Obviously, with enough interpretive leeway the "star map" could be seen as matching just about any arrangement of stars **(Sheaffer 2007)**. Figure 2 shows one such attempt by a Ufologist.

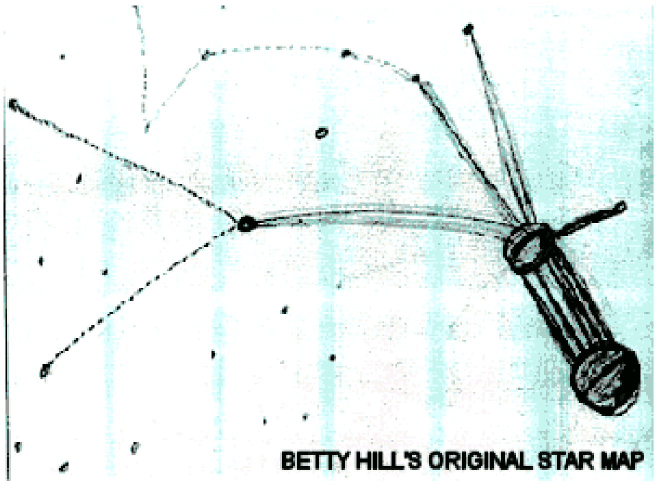

Figure 2. Betty Hill's original star map.

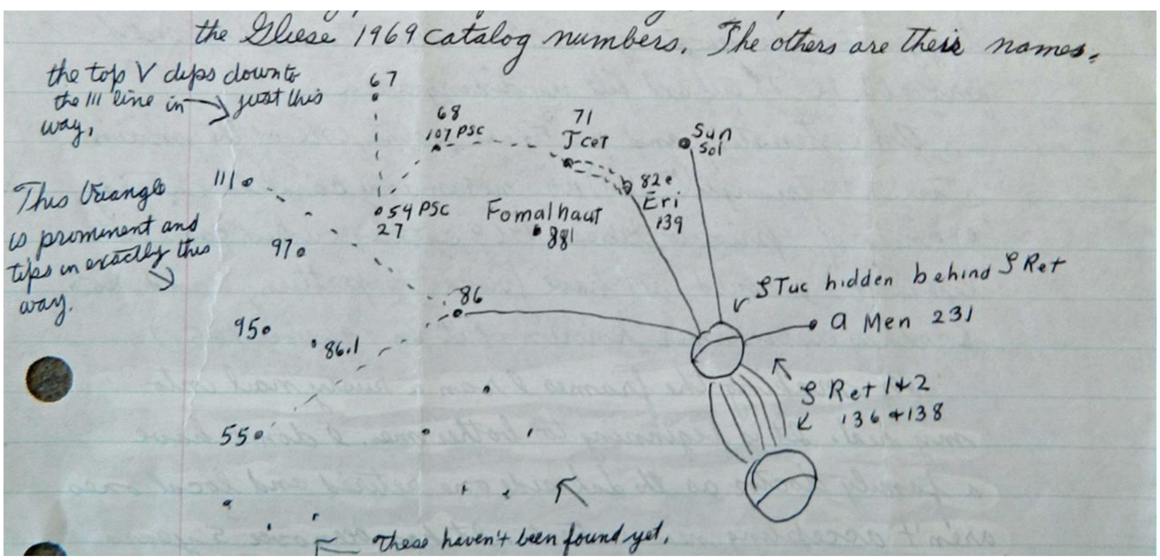

Figure 3. Attempt to fit the Hill star map to known stars, by Marjorie Fish.

Another item of evidence cited by Ufologists in support of the claim that the Hills were genuinely abducted is the presence of some pink stains on the dress of Betty Hill. The dress is said to have been worn at the time of the event, and Betty Hill claimed she afterwards removed the dress, placed it in her wardrobe, and then never removed it or wore it again. After a hypnosis session in 1964 the dress was retrieved, and it was noticed that a pink powdery substance had covered the dress **(Sheaffer 2007)**. The substance blew off but left some stains on the dress. Samples of the stained portions of the dress were taken for analysis. Apparently, these stains could not be sufficiently replicated using various chemicals and this is cited as a reason to think the stains were of extraterrestrial origin **(Sheaffer 2007)**. Other tests detected the presence of a non-soap, detergent-like substance, and showed that the stained parts of the dress induced higher energy degrees in water. Sheaffer **(2007)** notes that what is meant by "higher degrees of energy in water" is left unexplained. He also points out that an item of clothing left alone in a wardrobe for years will typically be exposed to biological substances from such things as mould and insects. It is also important to remember that the Hill abduction story owed its genesis to memories "recovered" via hypnotism. The ability of this process to produce veridical memories has been fiercely contested by psychologists **(Loftus 1997, 71)**. Experiments have shown that such recovered memories are often confabulations created by a highly suggestible mind under hypnosis. Memories are often unreliable at the best of times, and memories which are recalled when a person is in a highly suggestible state are particularly unreliable **(Loftus 1997, 75)**.

6.3. Ancient Aliens.

Another claim made to support the position that aliens are (or at least have been) here on Earth is that many of the monuments and structures built during this planet's past are far beyond what human beings were capable of building at the time they were built. Structures used to justify this claim include the Pyramids of Giza, Stonehenge and Pumapunku in Bolivia. While each of these structures are certainly impressive, are they advanced enough to require the intervention of extraterrestrials? Mainstream scientists and archaeologists don’t think so. They have described methods by which the humans of the time could have built them.

Here I will focus on the Pyramids of Giza since they are the structures most commonly cited as evidence by proponents of the ancient alien hypothesis. The Pyramids are certainly immensely impressive structures. The largest of the three pyramids is the Pyramid of Khufu (also known as the Pyramid of Cheops or the Great Pyramid), which is thought to have had its construction completed around 2560BC. It presently stands at around 138 metres high, but it once stood at around 146 metres high. It is built from approximately 2.3 million large stone blocks, most of which weigh two to three tons. It once had a white limestone casing. Khufu’s Pyramid remained the tallest artificial structure on the planet for 3,800 years, until the Lincoln Cathedral surpassed it in the 1300’s.

The main line of evidence for the ancient alien hypothesis, as it relates to the pyramids, is the share size of the pyramids and the scale of the task of building them. Proponents of the ancient alien hypothesis contend that the Egyptians of the time did not have the capability to quarry the stone or to move the blocks into position, or at least, not in the numbers needed. The problem with this claim is that we have a number of perfectly plausible hypotheses about how the pyramids could have been constructed by the Egyptians. One theory is that the blocks were hauled up a ramp which was progressively lengthened during construction **(Edwards 2003, 341)**. Another theory proposes that a series of pulleys and levers where implemented to raise the blocks up the pyramid **(Edwards 2003, 341)**. The people of ancient Egypt could have moved the massive stone blocks using a sled and rollers with water as lubricant **(Edwards 2003, 343- 346)**. Estimates of the number of labourers needed to construct the Great Pyramid vary, but a possible number was estimated by Craig B. Smith **(1999)** who used the modern program management process of “critical path analysis” to arrive at a figure of 13,200 regular labourers with a peak of 40,000 labourers, with this number of labourers the construction of the pyramids would take a total of ten years, with the workers assembling the pyramid by placing 180 blocks per hour over a ten-hour work day. These methods were achievable by the people at the time using the tools they had available, without any need for intervention by non-human intelligences.

A similar line of evidence that is sometimes cited in support of the X-files solution concerns the purported existence of alien-constructed monuments beyond Earth. This evidence mainly consists of low resolution photographs from early space missions. In particular the now infamous “Face of Mars” comes from a Viking 1 photograph and appears to show a huge monument in the shape of a face in the Cydonia region of Mars. However more recent, much higher resolution photos have shown that the apparent face was merely an optical illusion produced by shadows and blurring. It is now revealed as simply being a rock mesa. A curious twist in the “Face of Mars” story is that the existence of this mesa and others like it in the same area does in fact lend credence to the possibility that Mars once had oceans of water, these mesas being similar to those in areas on Earth where there were oceans in Earth’s geological past **(NASA 2001)**.

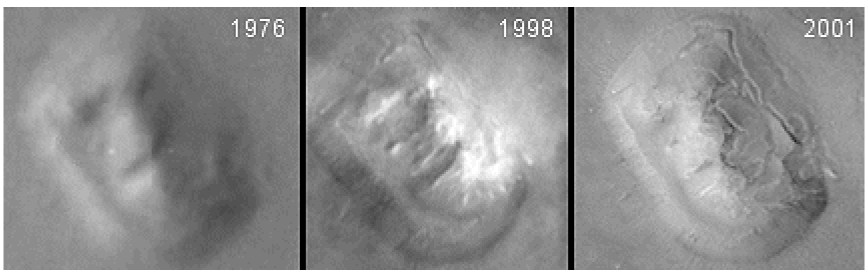

Figure 4. “Face of Mars” photos over time (NASA 2001)

6.4. Conspiracy?

Ufologists commonly (but not invariably) believe that there is a conspiracy to hide the truth about alien visitation **(Sheaffer 2009)**. The sorts of criticisms of their theories I have described above are considered by them to be a part of this conspiracy, whether known or unknown to the one who is doing the criticizing. This conspiracy is often said to be conducted by the government or secret bureaus within the government. This purported conspiracy is used to explain why people don’t know of, or are dismissive towards, the claims made by the Ufologists **(Sheaffer 2009)**. It is easy to see why these claims of conspiracy are not scientific, since any contrary evidence or lack of evidence for Ufologist claims is simply transformed into evidence of the conspiracy. This makes the Ufologists hypotheses unfalsifiable.

This section has been cursory by necessity. I have merely attempted to demonstrate the weakness of the Ufologists evidence and of their position in general. My conclusion is that, at least until such a time as the Ufologists produce much stronger evidence for their view, the X-files solution to the Fermi-Hart paradox should not be taken seriously.

Chapter 7: Conclusion.

In the above chapters I have explored a wide array of possible solutions to the Fermi-Hart paradox. In this final chapter I will summarize my findings. The solutions I have examined, together with a brief summary of what they say are listed below:

- *The Zoo Hypotheses.* These solutions propose that aliens are intentionally keeping themselves hidden from humanity. They vary in how they explain how and why the extraterrestrial intelligences are doing this.
- *The Transcension Hypothesis.* This hypothesis proposes that extraterrestrial intelligences are undetectable due to their existing within very small and fast computers. Two versions of it can be distinguished.
    - *The full version.* In its complete form, as articulated by Smart**(2012)**, this version contains a number of additional, and unnecessary, propositions, including, for instance, the claim that such intelligences will migrate to the event horizons of black holes.
    - *"Isolated transhumanism".* This is Smart's Transcension Hypothesis with the unnecessary propositions removed. It retains only the core idea that intelligent technological civilisations will merge with very small and fast computers.
- *The First Great Filter.* This solution argues that the reason we don't detect extraterrestrial technological intelligences is that they don't exist in the first place. It comes in various forms.
    - *The Rare Earth hypothesis.* It is claimed that planet's suitable for life are very rare.
    - *The Neocatastrophism hypothesis.* It is claimed that life is typically wiped out quickly, preventing technological intelligences from evolving very often.
    - *Improbable intelligences solution.* It is claimed that technological intelligence has a very low intrinsic likelihood of evolving even on a long-lasting planet with a lot of life.
    - *The theistic solution.* It is claimed that a deity restricted technological intelligence to humanity.

- *The Second Great Filter.* This filter argument proposes that we don't find extraterrestrial intelligences because they have a high probability of destroying themselves before becoming detectable. Evidence consists of the many dangers that technology appears to pose to the one known technologically intelligent species in the universe, ours. It comes in two major forms:
    - *Environmental version.* Technological intelligences will, perhaps inevitably, destroy their environments due to their own technological advancement.
    - *War version.* Technological intelligences will, perhaps inevitably, destroy themselves due to their violent and competitive natures.
- *The X-Files solution.* This response to the Fermi-Hart paradox claims that extraterrestrial intelligences are already on Earth, or have already been on Earth—from which it would follow that this paradox is premised on a false assumption.

Now, which of these solutions are the most credible? In answering this question, I will divide the proposed solutions into three categories - the *implausible*, the *moderately plausible* and the *plausible*.

Implausible
-The Zoo Hypotheses.
-The full version of the Transcension Hypothesis.
-The X-Files solution.
-The theistic version of the First Great Filter.

Moderately Plausible
-The Rare Earth Hypothesis version of the First Great Filter.
-The Neocatastrophism hypothesis version First Great Filter.

Plausible
-The isolated transhumanism version of the Transcension Hypothesis.
-The improbable intelligences version of the First Great Filter.
-Second Great Filter.

The hypotheses that I have categorised as “implausible” are not necessarily incorrect. Any one of them could in principle offer the correct explanation of the silent sky. But they are hypotheses that, in my view, make especially strong claims that are especially weakly supported by currently available evidence as to how life and the universe operate. The hypotheses I have classed as “moderately plausible”—namely, the Rare Earth Hypothesis and the Neocatastrophism hypothesis—are both First Great Filter arguments. Both are these hypotheses are built on a scientific foundation, but both are rely on strong assumptions (about the rareness of Earth-like planets, and the frequency and impact of catastrophic events) that are not strongly supported as of yet. The three hypotheses I have listed as “plausible” are those that, in my view, conform best to our present understanding of the how the laws governing the universe operate, and—at least in the case of “isolated transhumanism” and the Second Great Filter—to how technological intelligence appears to behave. The three “plausible” solutions are mutually compatible, as none them exclude the other solutions also operating. This raises the possibility of two or more of the three “plausible” solutions being true at once, in what could be termed a “combination hypothesis”. If the three most “plausible” solutions are all true simultaneously then the chance of us detecting any technological civilisations in our galaxy becomes very small.

Which of these solutions is the most plausible? If there was a clear answer to this question, then there would be a clear solution to the Fermi-Hart paradox. Unfortunately, however, I don’t think there is any one clear victor. It is easy to imagine that any one of the three proposed solutions I have listed in the “plausible” category might be true. I see no clear justification for favouring one of them over the others.

However, the fact that there is no single plausible solution to the paradox doesn’t mean that no progress has been made towards solving the paradox. To the contrary, the existence of three perfectly plausible solutions means that there is no real paradox. I began this essay with the observation that developments in astronomy have revealed that within our galaxy alone there may be as many as one hundred billion extra-solar planets **(NASA-JPL 2012)**. Given this, it is statistically likely that at least some of those worlds may contain life and some of those may contain intelligent life. Given the sheer number of these worlds, why do we not observe any other intelligent life in our galaxy, aside from ourselves? The Fermi-Hart paradox arises from these two contradictory states of affairs within our understanding of the universe—namely: (i) the observation that the galaxy contains many potentially habitable worlds on which technological intelligences could arise; and (ii) the absence of any evidence of their existence. I have endeavoured to analyse a number of proposed solutions to determine if any are satisfactory in solving this paradox, and it turns out that several are satisfactory. This effectively removes the paradox. Admittedly, all three hypotheses I have categorised as "plausible" have somewhat bleak implications. The "improbable intelligences" version of the First Great Filter implies that the universe is a lonely place. The Second Great Filter implies that our own technological civilization is probably about to self-destruct. The "isolated transhumanism" version of the Transcension Hypothesis implies that it is instead likely to retreat into a virtual reality—which will be seen by many people as an ignominious end for our species. But, whether they are bleak or not, the reality is that these are all potentially the reason for the silent sky. The mere fact that a hypothesis has unpleasant implications doesn't make it false.

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